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13.	4 ,,	1942* (Nos. 1 and 2).	26.	3 ,,	1955.

AGRICULTURAL CIRCULAR, 1920-25

NUMBERS and year of issue of the "Agricultural Circular":—

Vol. 1, 1920, 12 numbers. Vol. 4, 1923, 1 number.
2, 1921, 5 ,, 5, 1924-5, 2 numbers.
3, 1922, 4 ,,

As number 4 of Vol. 3 was printed as "Volume 4" and number 1 of Vol. 4 as "Volume 5" it would appear from an inspection of a complete set that Volume 4 comprised only a number 4 and that there were two issues of Volume numbered as 5, No. 1.

ANNUAL BULLETINS, 1931-38

COPIES of Annual Bulletins of Divisional Reports for the year 1933 and 1934 ONLY are available.

AGRICULTURAL BULLETINS, 1911-55

A FEW copies of the following bulletins are available at the prices shown. Other Bulletins previously listed are out of print.

No. 1. Sisal Hemp in Fiji, by C. H. Knowles, 1911. Price 2s.
7. A Mission to Java for a Coleopterous Pest of Bananas, by Jepson, 1914. Price 2s. 6d.
23. Insect Pests of Fiji, by R. J. A. W. Lever, 1946. Price 1s.
24. The Botanical Gardens, Suva, by J. W. Parham, 1948. Price 1s. 6d.
25. Copra Drying and Copra Driers, by W. J. Blackie, 1950. Price 1s. 6d.
26. Mechanisation of Rice Padi Cultivation by R. R. Mason. Price 2s. 6d.
28. Soil Erosion and its Control in Fiji, by C. E. Whitehead. Price 2s.
29. Annual Reports of Divisional and Specialist Officers 1954. Price 4s.
30. The Grasses of Fiji, by J. W. Parham. Price 5s.

AGRICULTURAL REPORTS

RECENT reports on Agricultural subjects are available as follows:—

Rhinoceros Beetle Eradication Board. Report C.P. No. 39, 1954. Price 1s. 6d.
Coconut Rehabilitation Committee 1954. Report C.P. No. 40, 1954. Price 1s.
Department of Agriculture Annual Report, 1953. C.P. No. 37, 1954. Price 5s. 6d.
Department of Agriculture Annual Report for 1954. C.P. No. 9, 1955. Price 2s.
Report by Sir Geoffrey Clay on his Visit to Fiji in 1954. C.P. No. 31, 1955. Price 1s. 6d.
Department of Agriculture Annual Report for 1955. C.P. No. 8, 1956. Price 2s.

OTHER PUBLICATIONS

A FEW copies of the following important book are available:—

The Coconut Moth in Fiji, by J. D. Tothill, H. C. Taylor and R. W. Paine. Imperial Bureau of Entomology, 1930. Price £1.

FORTHCOMING PUBLICATIONS

THE following publications are in the press and will be available shortly:—

Bulletin No. 31 ... ... The Declared Noxious Weeds of Fiji and their Control, by T. L. Mune and J. W. Parham (approximately 72 pages and 33 illustrations).

Book ... ... The Fishes of Fiji, by H. W. Fowler (approximately 600 pages and 200 illustrations).

Agricultural Journal

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ISSUED BY THE DEPARTMENT OF AGRICULTURE, FIJI

EDITORIAL . . .

Man may use himself like a beast of burden, fetching and carrying, sweating and groaning, or he may make use of an animal and a wagon to do this for him.

And even though it is not easy to show how to " hitch your wagon to a star ", the first article in this issue of the *Journal* does at least show, in practical fashion, a number of ways in which a suitable vehicle for the farm may be constructed.

If farmers would use a cart instead of a *ghazetta* or sledge, they would cease to make those eroded tracks on their farms which scar the land and increase the damage of every heavy rainfall.

There are other good reasons for the use of carts ; it will be sufficient to mention one that comes to mind. There must be many instances in which our export bananas could be transported carefully in rubber-tyred carts, to be delivered in good condition at the packing or forwarding station, instead of being bumped about and finally dumped down with a sigh of relief by a human carrier.

A farm cart may help to solve at least one of your problems.

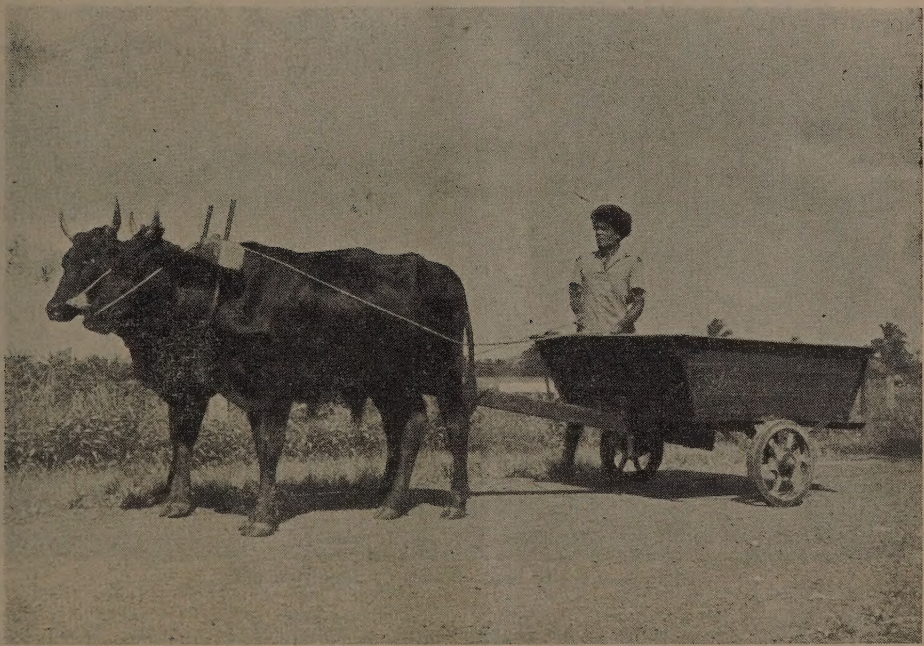

Plate 1—Imported Talbot cart frame, fitted with timber locally.

AGRONOMY . . .

FARM CARTS

BY R. R. MASON

Farm transport on peasant holdings is commonly provided by bullock-drawn sledges. These damage roads and are liable to cause soil erosion on hill slopes. In an investigation into the possibility of replacing sledges with cheap wheeled carts, three types of wheels and axles were imported and bodies built on them locally. Details of these carts are given. Costs varied from £22 to £26. The use of axles from old motor vehicles is also discussed.

Most Indian farmers or small-holders and many Fijians too, uses a bullock sledge or "ghazetta" to carry their produce. This sledge is usually made out of a forked branch about six inches in diameter, drawn by a chain from the junction. The arms are four or five feet long, and a rough framework across them allows three or four sacks of padi or a load of sugar cane to be carried. The great merit of these sledges lies in their simplicity; the farmer can build one himself with a neglible outlay of

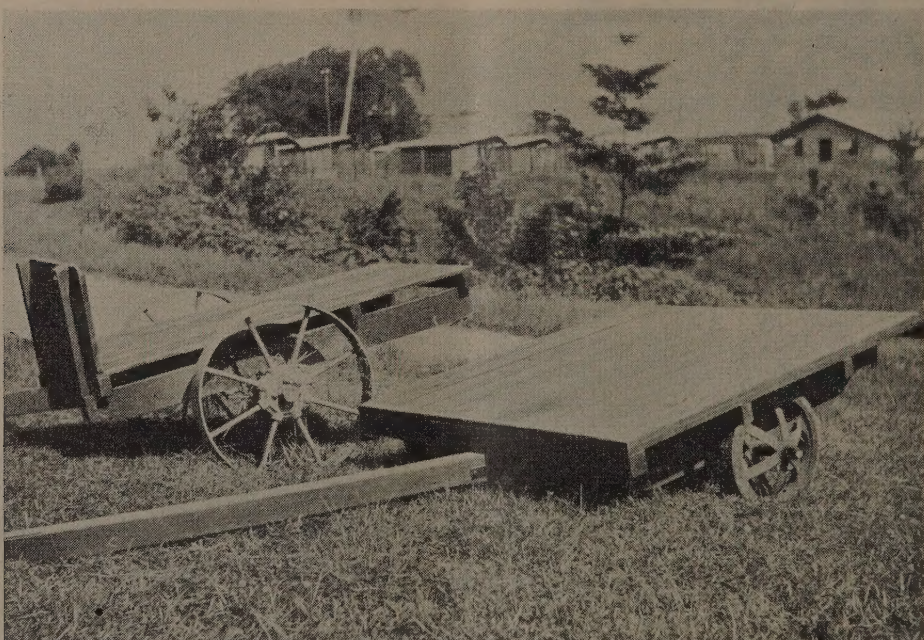

Plate 2—Locally made bodies on imported axles.

money. But they carry only small loads, and are responsible for much damage in the dry zones of the Colony; for repeated use in one place soon destroys whatever protective vegetation there may be and creates a track along which storm water will flow. The scraping action of the skids together with the effect of the water can cause severe gully erosion.

Simple bullock carts can be constructed from rough timber, solid wheels being made from sections of a log. Such a cart has been

described in this *Journal* by Mune (1953). The use of steel wheels and axles is naturally more expensive but results in longer life and easier draft. A firm in Ba is now building carts with small iron wheels. The tray which has low sides is 5 feet 6 inches long and 3 feet 6 inches wide, and the price is £25.

Efforts are being made to popularize carts in several of the Colonies, and Wills (1954) states that in Northern Rhodesia a grant of 50 per cent of the cost is made by the Government. In order to investigate the possibilities of encouraging the use of carts here, the Agricultural Advisory Council recommended that several types of wheels and axles be imported and that bodies be made locally. Wheels and axles were obtained from two firms, and different types of bodies were built on them at Koronivia as shown in Plate 2. A third firm supplied both wheels and axles and a complete metal cart frame; the latter is shown in Plate 1. Details of these, with landed costs, are as follows :—

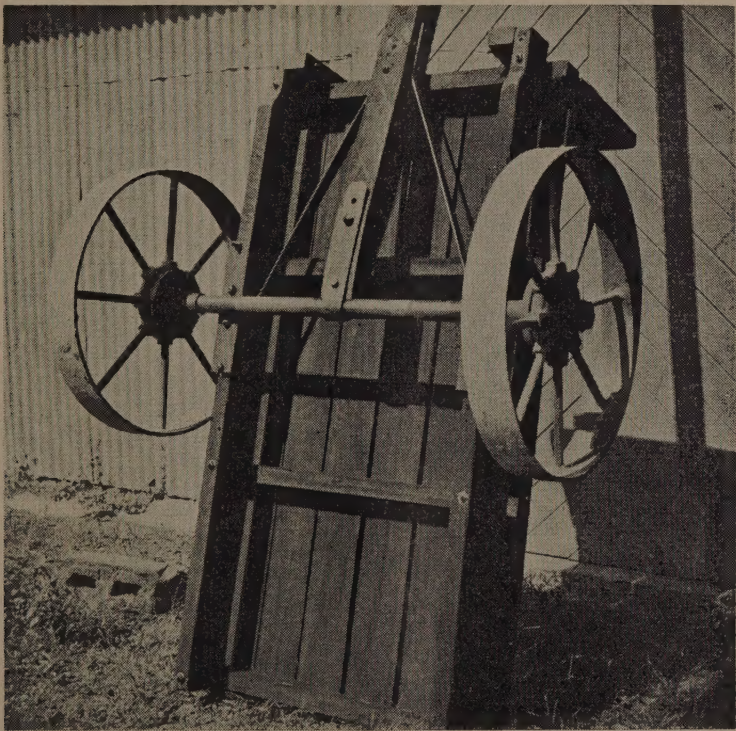

Plate 3—Details of construction of cart on Twose axle.

Type 1 (Plate 3).—The steel wheels are 30 inches in diameter and 4 inches wide, and fitted with replaceable bushes; the axle carries welded brackets. (Landed cost £15 16s. od. from Messrs E. V. Twose Ltd., Devon, England). The cart was built with a front board but without sides, the tray being 5 feet 9 inches long and 3 feet wide, and fitting between the wheels. In practice this has proved rather narrow; sides would be an improvement but would of course add to the cost. The total cost of the vehicle illustrated was £25 2s. od.

Type 2 (Plate 4).—The wheels are 18 inches in diameter with solid rubber tyres $2\frac{1}{2}$ inches wide, and are carried on a plain round axle so the track is 4 feet 2 inches. (Landed cost £12 5s. od. from Messrs. Cooper and Card Ltd., New Zealand. Because of the small diameter of the wheels,

it was easy to build the flat top over them. This tray is 6 feet long and 5 feet 4 inches wide, the total cost being £22 8s. od.

Type 3 (Plate 5).—Rubber tyred wheels 19 inches in diameter and 2 inches wide, fitted with ball bearings, are supplied by the Talbot Plough Company of South Wales either on plain square axles or with a complete metal cart frame. The latter cost £17 6s. od. and when fitted with timber floor, sides, and pole, the total cost was £26 11s. od. All necessary parts for the frame are supplied, and assembly merely consists of bolting them together, and then cutting and fitting the timber. The plain axles cost £10 12s. od. for a track width of 4 feet 6 inches, and £11 18s. od. for a track width of 5 feet 6 inches. They are thus cheaper than the comparable Type 2.

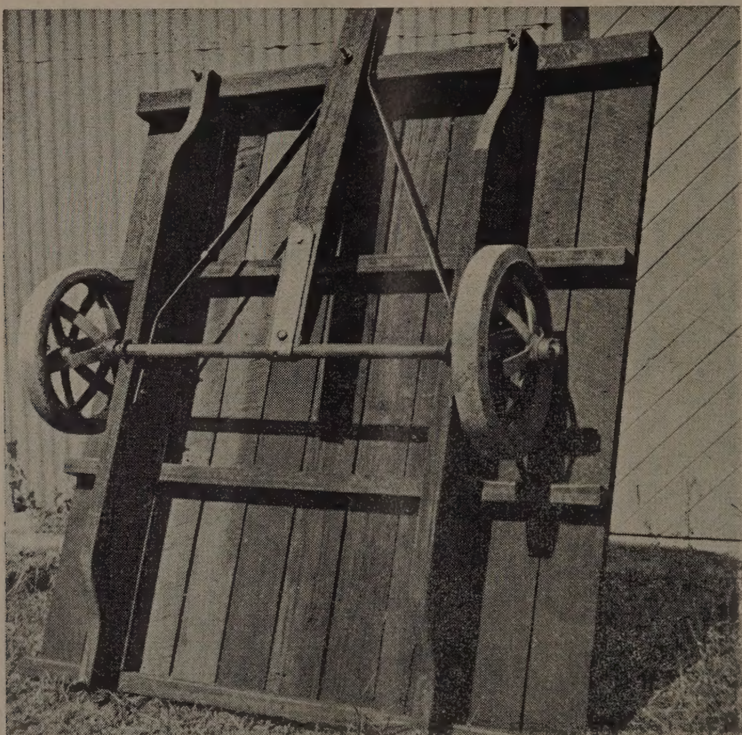

Plate 4—Details of construction of cart on Cooper and Card axle.

The carts illustrated are not of course the only designs which can be built on these axles, but they have proved satisfactory in use and have allowed the different axles to be compared.

Brakes have not been provided but would be desirable for work on hill slopes. For soft ground, the small diameter wheels are less suitable than the Type 1 steel wheels, owing to the high draft of the former. However, their advantage lies in use on hard roads, and especially on tar-sealed roads.

One idea which is surprisingly little used is the use of old car or lorry axles, with pneumatic tyred wheels. There are numbers of such axles lying around on scrap-heaps. The tyres do not need to be in very good condition, provided there are not actually holes in them. If a front axle is used, movement at the king pins must be prevented by cutting the track rod and welding the ends to the axle. After the springs are removed, the axle can be used either way up. Reversing it is more satisfactory but

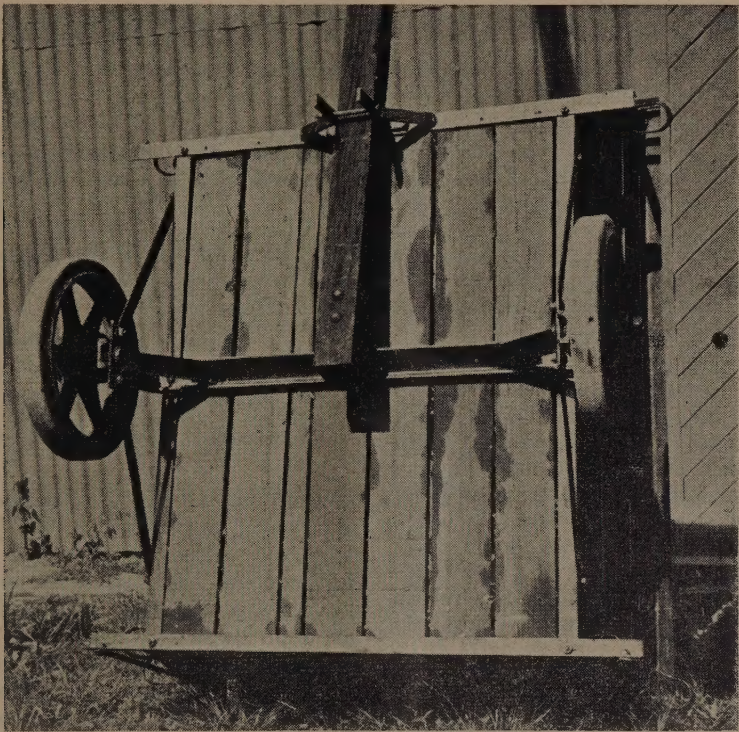

Plate 5—Details of construction of Talbot cart frame.

it is then necessary to weld on a plate to carry the beams of the cart. If a rear axle is used, the springs are removed and the differential gears are taken out, and a plate is then bolted over the differential case in place of the propeller-shaft.

RECOMMENDATIONS.

1. Where the vehicle is to be used solely on earth tracks or metalled roads, Type 1 with large diameter and broad tread is recommended.
2. Where the vehicle will be used on sealed roads, one of the rubber-shod types is recommended.
3. Old car wheels with tyres are highly satisfactory for all conditions.

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THE IMPORTANCE OF THE FLOODING OF RICE

BY N. G. CASSIDY AND S. A. SINGH

Rice is a semi-aquatic plant and it grows luxuriantly under conditions which would quickly prove lethal to dry land species. The growing of upland rice is of course common, but this is only resorted to when water is scarce, and the available evidence suggests that padi yields are better than yields from upland rice.

In Fiji, rice is usually grown in a very haphazard manner and little attempt is made to secure that control of water whch is essential for successful padi crops.

The usual practice in Fiji is to plant on land which has not been provided with check banks and which consequently lacks the first essential for water control. Moreover the land has usually been neither graded nor smoothed and consequently has numerous low spots and hillocks which give rise to a wet and dry patchwork effect between periods of rain. The dry areas allow weeds to grow that would be killed by submersion. On the other hand young rice may be drowned out in the low parts of the plot during continuous wet weather. A properly bunded, graded and smoothed plot will retain a uniform depth of water and any superabundance can be run off as desired through openings in the check banks.

The purpose of this article is to show the supreme importance of water control for the proper cultivation of padi and to indicate the rewards which may be expected by the application of this simple principle.

EXPERIMENTAL EVIDENCE.

An experiment was carried out in a greenhouse using pots five inches in diameter; the rice variety was New Guinea and the soil was a typical padi-growing soil, Navua clay loam. Two seedlings were planted in each pot and the treatments shown below were applied at 28 days. Other experiments having shown that this soil needs phosphate to produce a good crop, an application of calcium monophosphate equivalent to 4 cwt. superphosphate per acre was made to all the pots 77 days after planting. There were three treatments :—

W. Pots were kept wet, that is to say, flooded.

D. Pots were kept dry; but the plants were not allowed to wilt for lack of water.

I. An intermediate treatment. The soil surface was wet, but there was no free water on the surface.

There were three replications of each treatment.

The intermediate "I" treatment in practice proved much like the wet "W" treatment and will not be considered in detail any further. As adequate-sized pots were not available at the time it proved difficult to maintain standing water in the "W" treatment pots at all times, and consequently many weeds succeeded in growing in these pots which would otherwise have been suppressed.

The plants in the "D" pots were never allowed to show water stress and they never wilted, although the surface of the soil was always dry.

Plate 1 compares a pot from the "W" treatment with one from the "D" treatment. It is considered that if more effective suppression of weeds had been obtained in the "W" treatment the results would have been even more striking. In the event, grasses which appeared in the "D" pots were suppressed by the "W" treatment.

Control of water alone has therefore made the difference between runts and large healthy plants. The healthy plants were harvested at 167 days when the grain had matured and the runts were allowed to grow on; eventually, at 205 days, the runts produced small seed heads but the difference in grain weight was even more marked than the difference in straw. Table 1 sets out the yields.

The four-fold increase in grain weight due to flooding is most impressive.

It was noticeable that the flooding allowed tillering to take place, even though under the particular conditions, only one of the tillers finally survived to bear a seedhead. On the other hand with the "D" treatment there was no sign of tillering at all.

[*Photograph by R. R. Wright*]

Plate 1—Dry rice versus flooded rice. The only difference between the two pots is that whilst the one on the left received sufficient (but not excess) water, the one on the right was kept flooded. The variety is one which is adaptable to both lowland and upland cultivation.

TABLE 1

Treatment	Age in days, at maturity	Mean Yields (g) Grain	Straw	Phosphorus in straw (%)	Nitrogen in straw (%)
Wet (W)	167	2.07	3.57	0.073	0.59
Intermediate (I)	167	1 66	2.86	0.055	0.45
Dry (D)	205	0.52	1.47	0.036	0.36
Significant Differences P= .05	..	0.41	0.60	0.014	0.06
Significant Differences P= .01	..	0 57	0.84	0 020	0.08
Significant Differences P= .001	..	0.80	1.19	0.029	0.12

Another striking feature was the higher degree of fertility of earheads on the "W" plants. The "D" plants had not only smaller panicles but there were many empty glumes.

OTHER EVIDENCE.

Corroboration of these findings is not lacking. Unknown to the authors, a very similar pot experiment was carried out by R. E. Shapiro and an advance report of this work has just come to hand. Shapiro (1954) found that flooding was beneficial from a number of different aspects. Firstly it provided the physiological conditions best suited to the plant. Secondly it increased the amount of phosphate available in the soil. Thirdly it allowed of more effective use of applied phosphate fertilizer. It also increased the nitrogen available both from the soil and from nitrogen fertilizer.

The present experiment did not confirm Shapiro's finding that submergence of the soil increased the available phosphorus in the soil, though our tests may well have failed to do so because they were made after the growth of the crop and therefore after the extraction of considerably more phosphate from the flooded pots, whereas Shapiro's were made before and during the growing of the crop.

Field evidence is also available from Fiji in the form of a report by R. R. Mason (1953) on the results of bunding, with and without irrigation, at the Principal Experiment Station, Koronivia. Two small portions of a large unbunded area were properly bunded, and one of these was irrigated in addition. The bunded portion outyielded the main unbunded area by fourfold, and with irrigation as well there was a further increase in yield. Weeds were noticeably bad on the unbunded area and this factor alone could clearly account for a considerable difference in yield.

At an even earlier date, Lord and Fernando (1931) working in Ceylon with cement pots in the ground provided with a small opening for slow drainage, found that continuous submergence of the surface to a depth of 3 to 4 inches gave higher yields of grain and straw than a system of submergence for 14 days followed by drying for 7 days.

It is also significant that in the irrigated subtropical countries such as Australia, Italy and California where yields are highest, flooding and not intermittent irrigation is always adopted.

PRACTICABILITY OF FLOODING WITH NATURAL RAINFALL ONLY.

It is necessary to consider whether it is possible in Fiji to grow padi rice with rainfall as the only source of water supply. The total need for water consists of three parts, namely, water used for transpiration of the crop, water lost to the air by evaporation and water lost from the soil by deep percolation.

If it be taken that 300 parts of water are required in transpiration to produce 1 part of dry weight, a one-ton-to-the-acre crop of padi (grain) or $2\frac{1}{2}$ tons total dry weight would require 8 inches of water to mature the crop. This would amount to about $2\frac{1}{2}$ inches per month over the growing season.

The rate of evaporation is not accurately known in Fiji ; in fact the only known data were acquired during 1949 at the Sigatoka Agricultural Station.*

In the following table both rainfall and evaporation are set out as well as the excess of rainfall over evaporation.

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Rainfall	5.2	7.2	9.7	9.0	11.0	7.4	4.8	2.8	3.0	3.2	3.9	3.7
Evaporation	2.6	3.5	4.5	3 9	2.6	3.5	2.1	2.7	2.2	2.5	2.6	4.3
Excess of Rainfall	2.6	3.7	5.2	5.1	8.4	3.9	2.7	0.1	0.8	0.7	1.3	0.6

This shows that for the rice growing season November to May an excess of water amounting to between $2\frac{1}{2}$ and $8\frac{1}{2}$ inches can be expected in each month, if transpiration and soil percolation are ignored.

With transpiration at $2\frac{1}{2}$ inches per month there would need to be very little percolation if the establishment and maintenance of free water in rice fields is to be possible.

Experience on the Murrumbidgee Irrigation Areas in Australia has shown that, depending on the nature of the soil, percolation may vary from $1\frac{1}{2}$ inches to 15 inches per month. The factor of soil percolation is therefore the most critical of the three

* Subsequently a mean value of 2.4 inches per month has been obtained for July-August, 1955, in Suva. Evaporation readings are now being made again at Sigatoka Agricultural Station as part of the routine meteorological data.

which are concerned. On a typical padi soil such as Tokotoko clay loam percolation must be very low because, even when run-off is permitted, these soils retain a water-table close to the surface even in dry seasons. For more permeable soils puddling before transplanting the rice would be necessay, and this could easily be accomplished during the land preparation.

All the above data on rainfall and evaporation apply to Sigatoka. In the wet zone, rainfall for the rice season is 3 inches to 5 inches per month greater, and evaporation must be somewhat less, than for Sigatoka ; so that, provided soil percolation can be kept down to a few inches per month, progressive flooding with the progress of the wet season is quite feasible.

The total rainfall for Nadi during the rice season is the same as for Sigatoka. It may therefore be said that provided the soil is not too permeable, the growing of fully flooded rice should readily be possible in the wet zone and it should even be feasible in the dry zone.

DISCUSSION.

The present article does not set out to compare the growth of dry-land rice using dry-land varieties (with or without full mechanization), with wet-land rice. There is some land which, if it is to grow rice at all, must obviously grow dry-land rice ; but there is much of our low-lying land which is eminently suitable for flooding. If this land is not cultivated by flooding it will never be fully productive.

In these discussions we are concerned only with the growing of the crop effectively and not with the particular mechanics of cultivation which may be employed. This may be peasant agriculture with simple ploughs drawn by animals, and hand reaping of the crop ; or it may be fully mechanized cultivation with combine havesting ; or it may well consist of some system which is intermediate between the two.

In any case the benefit to be derived from flooding in the control of weeds alone is a very considerable one, so that flooding might well be profitable even on a soil too rich to show response to fertilizers. It is doubtful if any rice soils in Fiji would come in such a category. In the main the typical padi soils of Fiji are very deficient in phosphate, though less so in nitrogen, and it is presumably the greater available phosphate that accounts for much of the increase in yield. It has been shown by one of us (Cassidy 1955) that flooding also considerably increases the effectiveness of Lau (Ogeadriki) phosphate on the two padi rice soils Navua clay loam and Tokotoko clay loam. Since Lau phosphate contains more iron and aluminium than calcium, and is in fact like a red loam soil in appearance, the same beneficial process of rendering phosphorus more soluble may be concerned in both the natural soils and in the fertilizer.

The effectiveness of nitrogen can be well understood when it is considered that whereas anærobic conditions prevent the formation of nitrate in soils they do not prevent the formation of ammonium ions ; and it is well recognized that rice can not only absorb nitrogen in the form of ammonium ion but even shows a preference for ammonium over nitrate ion.

It is not of primary importance whether we could now sell much more rice at the present prevailing price or not, because this is a method of cultivation which will essentially *reduce the cost of production*. We can either cultivate the same quantity of land and export rice, because we will be able to produce our rice more cheaply ; or we may find it uneconomic to export, in which case much land can be released for growing other crops and this land will naturally be the land which is least suitable for flooding and is consequently better able to grow other crops than rice.

The present article has not dealt with the question of the use of fertilizers. Other work has shown that the two most common soil types in Viti Levu suitable for the growth of the padi rice, namely Navua clay loam and Tokotoko clay loam, both give large increases in yield from the use of moderate amounts (3 cwt. per acre) of superphosphate in conjunction with flooding. Extra nitrogen is only advantageous on these soils when a very large response has already been achieved by the use of phosphates. This work will be reported when all the results are available.

Finally it is worthwhile pointing out that the benefits of flooding are not necessarily directly applicable to reclaimed mangrove land where salinity and hydrogen sulphide are additional factors. Moreover it is important that ordinary padi land should be provided with efficient outlets in the check banks so that drying-out of the soil surface is possible in the off season.

SUMMARY.

The available evidence supports the view that flooding is successful because :—

(*a*) it automatically controls most weeds ;

(*b*) it provides physiological conditions most suited to rice ;

(*c*) more phosphate and nitrogen become available to the plant.

Whatever may be the processes by which additional phosphate and nitrogen become available, observable benefits to the plant are more tillering, higher fertility in the inflorescence and earlier maturity.

The poor yields of many of our padi soils could be transformed into very profitable harvests by the adoption of flooded cultivation especally in conjunction with the use of superphosphate.

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ANIMAL HUSBANDRY . . .

THE INTRODUCTION OF SANTA GERTRUDIS CATTLE INTO FIJI

BY A. F. S. OHMAN AND W. J. A. PAYNE

The total land area of the Colony is 4,500,000 acres and of this approximately 1,500,000 are natural grassland or reed (gasau) country. A soil survey of Viti Levu, representing more than half the land area of the Colony has been completed and this shows that the largest area of fertile soil still unexploited is the hill land of the dry and intermediate zones. This hill land is very suitable for grazing and with enclosure there is every possibility of using it for the production of beef cattle. If the beef cattle industry were expanded in this area it could play a very important part in the economy of Fiji.

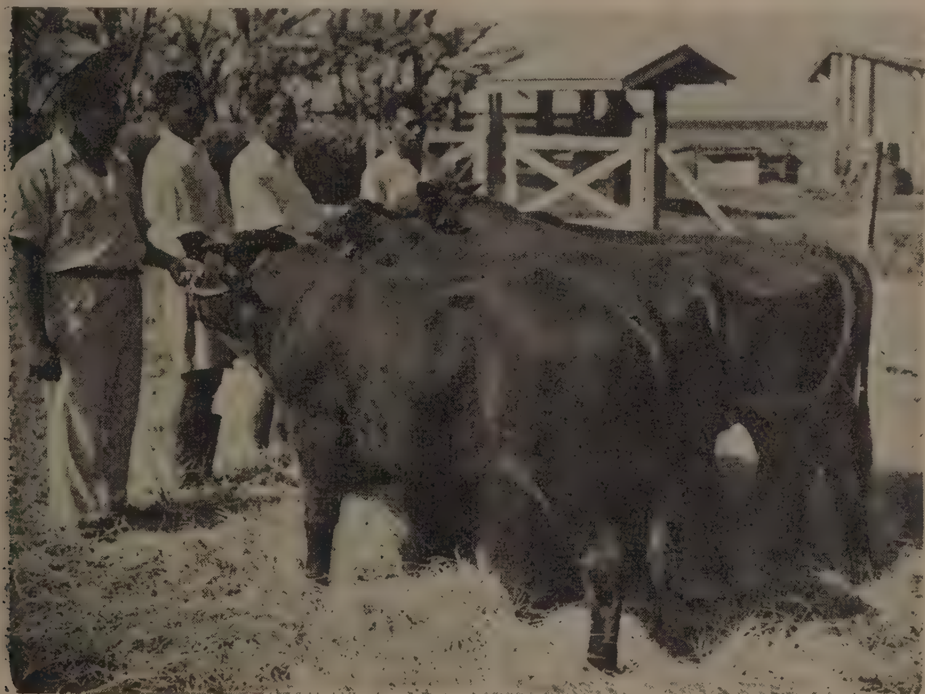


Plate 1—A group of Santa Gertrudis bulls recently imported to the Colony.

With a steadily increasing population the demand for meat and meat products is growing. Increased consumption is not at present being met by increased local production of beef but by an expansion of imports. It is true that the animal protein requirements of the local population could be satisfield without expanding beef production, but the indigenous population have acquired a taste for meat, above all, beef. This is particularly the case in the urban districts where numbers of industrial and city workers are congregated. In these areas fish, the traditional animal protein food of the indigenous people is in short supply and costly and demand is for the cheaper cuts of beef.

Since controls on the killing of cattle were lifted early in 1953 the number of cattle slaughtered has increased considerably. To meet this situation, Government is making an effort to encourage cattle raising in a number of ways, including the encourage-

Plate 2—A typical specimen of the imported Santa Gertrudis sires.

ment of pasture improvement, the control of noxious weeds, propaganda on the control of parasitism of young stock, and by investigation into the nutrition of livestock. Although the nutrition of animals is of the greatest importance and as practical stock-

men say, " ninety per cent of the breeding goes down the throat "; one of the most pressing problems of the beef cattle industry is to obtain a type of animal that is properly acclimatized to the country. Ranchers have imported Shorthorn, Red Poll, Hereford and Aberdeen Angus cattle in the past and although there are to-day relatively productive herds of Herefords and Red Polls and a small herd of Aberdeen Angus run on extensive holdings, the general consensus of opinion is that European type beef cattle are not completely acclimatized. Some Zebu cattle have been imported, mainly by the Colonial Sugar Refining Company for crossing with European type cattle to produce working bullocks for the cane farmers. Early importations were of the Ongole-Krishna Valley type and the last importation in 1938 was American Brahmans from Texas. Some of the best beef cattle to be seen in Fiji to-day are crossbreds with varying amounts of Zebu " blood ".

It was decided therefore to explore the possibility of introducng a new type of beef cattle into Fiji, the Santa Gertrudis. It was thought that there was a reasonable chance that animals of this breed would thrive in the dry zone of the Colony particularly as they were thriving under similar conditions on the island of Cuba. Early in 1952 a proposal was made to the South Pacific Commission that Fiji should act as a centre for stock importation and that one of the breeds that could be introduced should be the Santa Gertrudis.

Mr. R. J. Kleberg, part owner and manager of the King Ranch in Texas where the Santa Gertrudis breed had been developed visited Fiji during 1952 and discussed the merits of introducing the Santa Gertrudis breed with Government officials and other interested parties. In 1953 the Economic Review Committee recommended to Government that funds should be made available for the purchase of Santa Gertrudis stock.

Some time elapsed before the importation could be made as difficulties were encountered in purchasing the animals in Texas. Fortunately the King Ranch organization, in association with Australian beef cattle breeders, decided to bring a consignment of Santa Gertrudis cattle to Australia in 1952 and it became possible to purchase bulls from the first calf crop born in Australia. Four young bulls were selected and they arrived in the Colony in early April, 1955.

The Santa Gertrudis breed originated in Texas. It was recognized by the United States Government as a new breed of beef cattle in 1940 and is unique because it is the first distinctively North American breed of cattle and the first stabilized Zebu-European crossbred. Individuals of the breed are approximately three-eighths Zebu and five-eighths Shorthorn, the Zebu " blood " being probably derived from Guzerat, Nellore or Ongole, Krishna Valley and perhaps other strains, as several different breeds of Indian cattle were imported into the United States at the beginning of the century and crossbred with each other and with European cattle. It is only some 50 years since the first steps were taken to develop this breed and the breeders were assisted by the fact that large numbers of stock were available and that heavy culling could be practised. To-day virtually all Santa Gertrudis cattle can be traced back to one outstanding crossbred bull.

The breed is red or cherry red in colour. Animals of the breed have a reputation for rapid growth and early maturity and they have a good beef conformation. They thrive under Texas conditions, and can be considered to have inherited some of the hardiness and heat tolerance of their Zebu ancestors.

In Fiji it is usually considered that crossbred Zebu animals are difficult to handle and this has to some extent prevented the use of Zebu crossbred stock by the ranchers. It will be interesting to see if Santa Gertrudis can be handled as easily as European type beef cattle under Fiji conditions.

As the King Ranch Organization will only sell bulls any purchaser of Santa Gertrudis stock must use the bulls to " grade up " local cattle to the Santa Gertrudis type.

Government has not sufficient facilities on the two Agricultural Stations to embark on this type of project so it has invited the co-operation of local farmers and the four imported bulls will be used to grade up

different types of cattle including Hereford, Red Poll, Aberdeen Angus and crossbreds at different centres. One centre will be Sigatoka Agricultural Station where the Santa Gertrudis will be used to grade up Red Poll heifers with the object of producing a polled Santa Gertrudis type. Other centres will be properties in the dry or intermediate zones of the Colony.

It is hoped to have some 80 heifers mated to the Santa Gertrudis bulls during the next few months and by the first quarter of 1956 the first crop of crossbred calves should be available from which will be selected the first generation of crossbred heifers for use in the next stage of " grading up ".

" Grading up " is necessarily a slow process and crossbred sires will not be available for distribution until they are of at least seven-eighth's Santa Gertrudis " blood " and then only after rigid selection. It will be seven years before the first seven-eighth's Santa Gertrudis calves are born and a generation before sufficient numbers of them are available for large scale breeding purposes.

It is intended to rotate the bulls from centre to centre every two years, in order to reduce the amount of inbreeding at any particular centre. Information will be collected on the growth and reproduction of the Santa Gertrudis crossbreds and local type cattle of the same age at all co-operating centres. At the end of a decade sufficient informaton should be available to determine if the introduction of the Santa Gertrudis stock has been the success that it is now hoped it will be.

REARING CHICKENS

(TEXT OF A BROADCAST TALK)

BY R. R. MASON

When eggs cost 8d. each or more, and still are difficult to obtain, there is a lot to be said in favour of keeping backyard poultry. Household scraps can be used in their ration, and so the cost of feeding is quite low if a small number of birds is kept. Initial expenditure is necessary on housing, on wire-netting, and on feeding utensils and water troughs ; but this equipment should not need replacing except after quite long intervals. A bigger problem is provided by the birds themselves, for new birds should be brought into the flock every year or at least once every two years. This is because a hen lays progressively fewer eggs each year after her first laying season ; after her second season she rarely lays enough eggs to cover the cost of her food, so she is a better economic proposition in the pot than in the pen. For this reason, and also for the disposal of any surplus cockerels, most backyard poultry-keepers prefer a heavy breed, such as the Australorp or Rhode Island Red ; these give good table birds, the cockerels weighing six or seven pounds when six months old. On the other hand White Leghorns do lay more eggs and mature more quickly ; but they are nervous birds and are more easily upset, and are of little use for eating.

Now we turn to the question of getting, or of replacing, the stock. The simplest method is to buy pullets about 4 months old ; but only rarely can they be obtained, and their price is usually high. Of course, if you have a broody hen, you can set her, provided that you can obtain fertile eggs. A big hen will cover 13 eggs easily but a small one may only manage ten or eleven. Heavy breeds not only go broody more often than light breeds, but stay broody better and are less likely to desert their eggs. A hen should not have been broody for more than a week before setting ; otherwise the chances of her deserting the nest before the three weeks are passed are increased. The nest should be in secluded spot where the hen can settle down to the business of sitting still without interruption. She should be lightly dusted with DDT powder under the wings and around the vent, to ensure that she is carrying no lice. Water should be available to her at all times but she need only be fed once a day. If she doesn't leave the nest by herself, she should be gently lifted off, taking care that no eggs are lifted with her. The eggs should then be slightly dampened with tepid water ; this is most important in the last three days, in order to prevent the shell membranes hardening-up too rapidly so that the chicks can't get out of the shell. For the same reason it is useful to use an inverted turf as the foundation for the nest, making the actual nest out of straw or dry grass in such a way that it has no corners into which the eggs could roll. The hen should not be disturbed after the chicks start to hatch on the twentieth day until all are hatched ; then she should be moved to a flat floor to eliminate the risk of chickens falling out of the nest and being unable to get back.

The alternative way of rearing chickens is to buy them as day-olds, getting them either from Koronivia or from overseas. If you happen to have a broody hen at the time that your chicks arrive, you can put up to 18 under her ; they should be very gently put under her at night, so that next morning she thinks she has hatched them all herself.

Failing a broody hen at the right time, or for larger numbers, you need a brooder. With care, very good results can be obtained ; but carelessness and lack of attention will quickly result in heavy losses. The essential points are that the chicks must be warm and dry, and they must be fed " little and often " on suitable food, and they must have clean drinking water available at all times.

Dealing with these points in turn, warmth is provided by the brooder. There are two types—cold brooders which are easily made by a handy man, and heated brooders which

are more elaborate, but on the whole probably more satisfactory. Heated brooders are essential in temperate countries but are by no means essential here. Heat is supplied by a kerosene lamp or an electric heater, the temperature being held at 95° Fahrenheit for the first week and reduced by 5° each week until room temperature is reached. The important thing is to provide a place where the chicks can get warm quickly if they get cold outside, rather than to keep them in a warm atmosphere all the time. This of course is much more important in colder climates.

Heated brooders are used on the floor, and a circular barrier is placed round them to prevent the chicks from getting lost and being unable to find their way back to the source of heat. Unless this barrier is roughly circular, the chicks will find a corner and crowd into it. A strip of thin galvanized iron sheet is suitable. The area should be increased each day until the chicks have an area of about half a square foot each. The floor is best covered with deep litter—two to three inches of wood shavings alone or with rice bran. This need only be changed with each batch of chicks, so it reduces the work considerably. (It also keeps the chicks happy by letting them scratch and get exercise.)

An unheated, or cold, brooder keeps the chicks warm by preserving their own heat. It can be used inside a building like the heated brooder just described, or made rainproof and kept outside on a lawn.

It consists of a box to exclude draughts partially covered by a lid from which hang strips of sacking or old blanket, like curtains. These strips should reach almost to the floor and should be in rows two inches apart, with an extra row across each end. They should be split up from the bottom to allow the chicks to push through. A suitable size for the box is four feet square, with the lid two feet six inches square fitted centrally so that the chicks will not crowd into the corners. The lid should be 9 or 10 inches above the floor. The space surrounding the lid, between it and the edge of the brooder box, should be covered with small-mesh wire netting to make it rat-proof ; or if mosquitoes are bad, mosquito gauze can be used. A pop hole about 4 inches square should be cut in one side, and fitted with a slide. A brooder of this size, will hold 80 to 100 chicks up to 3 weeks or 40-50 from three to six weeks. They don't require a brooder after they are feathered.

For the first two or three days the chicks should be confined to the brooder box, food and water being placed on the clear part. After the first few days they must have more space for exercise, and this can be given by an outside run on short grass or on wire, or an indoor run. Short clean grass, to which no poultry have had previous access, is very good after the first week. Failing this it is safer to keep the chicks off the ground by using a fine mesh wire netting floor to the run, in order to reduce the risk of disease. An indoor run is very useful in wet weather, as chicks will not thrive if overcrowded by being confined to a brooder when the grass is wet. Deep litter is very good for indoor runs, and the floor of the brooder can also be covered with deep litter or alternatively with a thin layer of rice bran which will need cleaning out and replacing every day or two.

Dryness is the next point. If the brooder itself is to stay outside, then obviously it must have a watertight roof. However it is sometimes possible to arrange for the brooder to be inside a shed in which the chicks can be given an inside run, with a hole through the wall to allow them outside when the weather is fine. But while they are young, the chicks must be chased inside as soon as it starts to rain.

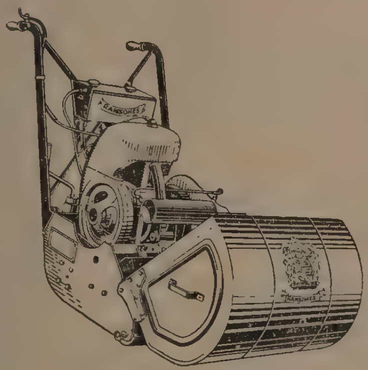
Dampness in the litter or on the brooder floor must be avoided at all costs, for otherwise the disease coccidiosis is almost inevitable. Special attention is necessary to see that the water supply does not cause a damp patch of litter around it. Either a slatted platform can be used, or the drinking vessels can be stood on a small heap of gravel.

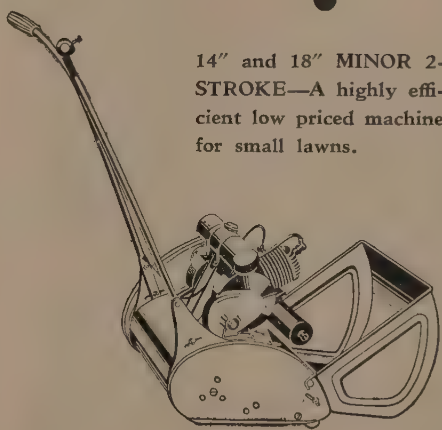
Wide shallow water dishes should not be used as the chickens get wet and then cold. In order to have a constant supply of water in a small dish, it is necessary to use some sort of fountain. A very simple one can be made from an inverted bottle held half an inch above a shallow cigarette tin—the kind that is 3 inches wide and 1 inch deep.

There remains the very important subject of feeding. Baby chickens need feeding at least 5 times a day, but they should never be given more food than they can clear up or it will go stale and if eaten later cause digestive troubles. For the first four days a simple food is rolled oats, mixed with a little moistened whole milk powder. A baked egg custard can also be mixed in. (This is more easily digested than hard boiled eggs.)

After four days, chick mash should be used, with cod-liver oil added. The chicks must be given some fine grit to enable them to grind up the grain portion of the mash. The feeds can be cut down to 4 a day after 2 weeks. If dry-mash hoppers are used the chicks can help themselves as they feel hungry, but a watch must always be kept to see that the meal is flowing freely. After 8 weeks the chick mash is gradually replaced by cheaper growing mash over a period of a month, and the feeds are reduced to 3 a day.

For small numbers of chickens it is easiest to buy ready mixed rations ; one large Suva firm carries a good range. But if you require information on making up your own rations, or on any other problem, then the Department of Agriculture will be glad to help you.





PIG FEEDING TRIALS

THE VALUE AND USE OF ANTIBIOTIC SUPPLEMENTS FOR RAISING PORKERS IN FIJI

BY W. J. A. PAYNE AND R. K. NAIDU

[*The Director of Agriculture advises that any reader interested in pig production who wishes to use Aurofac should communicate with the Department for information regarding the supply and use of antibiotic supplements.—Ed.*]

In the first article in this series the authors discussed the problems of pork producers in Fiji and showed that the use of imported animal protein feeds was economic for the large scale pig producer. They also suggested that a search should be made for new local sources of animal protein feed or for supplements that could be freely purchased and that could be used with local plant protein feeds.

In 1950 the first observations on the growth promoting effect of antibiotics in pig feeds were published in the United States by Jukes, *et al.* (1950), and these observations have since been widely confirmed by other workers. In 1953 a report was published by the Agricultural Research Council in the United Kingdom on the results of extensive trials with aureomycin and procaine penicillin supplements for fattening pigs. This report showed that generally the antibiotic supplements improved the rate of liveweight gain particularly when the pigs were fed plant protein feeds, and improved food conversion efficiency when used with both plant and animal protein feeds.

As soon as antibiotic supplements were freely available the possibility of using them in Fiji was investigated. It was thought that their use might assist the local pig producer to economize in scarce animal protein feeds, and as so little had been published on the use of antibiotic supplements for pig feeding in the tropics, that experience in Fiji might be valuable to pig producers in other tropical territories.

EXPERIMENTAL METHODS.

Two trials have been conducted. In the first, the use of the supplement marketed as "Distafeed" and containing procaine penicillin, and in the second, the use of the supplement marketed as "Aurofac" and containing aureomycin, were investigated.

Trial I.—Sixteen purebred Berkshire pigs, nine boars and seven gilts, were used. All the pigs were half brothers or sisters. They were selected from three litters born at approximately the same time and were arrange in four groups according to sex and weight. One pig from each group was then placed at random in one of the four feeding treatments. The treatments were (I) a high-level mixed protein feed similar to that used in the previous experiment and considered to be for practical purposes an optimal type ration, compared with (II) a low-level mixed protein feed, and (III) and (IV) two high-level plant protein feeds to one of which (III) procaine penicillin supplement was added at the rate of 5 gm. per pound of meal. Randomization took place one month before the experimental feeding began and during this time the pigs were fed in the experimental pens on a standard ration.

When experimental feeding began on the 14th May, 1954, the pigs were fed meal ration type A to 70 pounds liveweight and then meal ration type B until slaughter at approximately 120 pounds liveweight (Table 1).

All pigs were managed and fed meal, molasses and greenfeed according to the routine described in the first trial (Payne, *et al.* (1954)).

The pigs were weighed daily, a health record was kept and after each treatment group had passed the 120 pound liveweight level the pigs were slaughtered and hot carcass weights and certain body measurements were recorded.

Trial II.—Sixteen crossbred pigs, eight barrows and eight gilts, were used. Six of the crossbreds were first cross Tamworth x Berkshire and ten were second cross Large White x Tamworth : Berkshire. They were selected from three litters born at approximately the same time and were arranged in four groups according to sex and weight. One pig from each group was then placed at random in one of the four feeding treatments. The treatments were (I) the high-level mixed protein feed compared with (II) the high-level mixed protein plus aureomycin supplement, (III) the same ration plus aureomycin supplement but with no animal protein after the pigs weighed 90 pounds, and IV) the high-level level plant protein ration plus aureomycin supplement.

When experimental feeding began on the 15th of August, 1955, the pigs were fed meal ration type A to 90 pounds liveweight and then meal ration type B until slaughter weight at 120 pounds (Table 2).

All pigs were managed and fed meal, molasses, and greenfeed as in trial I, and were weighed daily until 120 pounds liveweight. It was not possible to obtain hot carcass weights and measurements in this trial.

RESULTS.

Trial I.—It will be seen from Table 3 that there were large differences in growth rate between the pigs fed a ration containing plant protein only (Group IV) and pigs on the other three rations. The differences were statistically highly significant ($p=0.01$) as were the differences in growth rate between the pigs in Group I and Groups II and III. The difference in growth rate between the pigs in Groups II and III was not significant. Thus reduction of the amount of animal protein in the ration by five per cent radically reduced the growth rate and the pigs on this treatment grew little better than those receiving plant protein plus a supplement of procaine penicillin. There were also, as would be expected, large differences in the time taken to reach slaughter weight at 120 pounds, Group IV pigs taking almost twice as long as Group I pigs.

The amount of food consumed together with the meal and greenfeed consumption per pound liveweight gain and the cost of meal per pound liveweight gain are shown in Table 4. Details of the cost of the rations are given in Table 5. It should be noted that the rations containing procaine penicillin were more costly than any of the other rations.

The pigs in Group I had the lowest meal consumption per pound liveweight gain, it being significantly lower ($p=0.01$) than that of the pigs in Groups II, III and IV. There were no significant differences in economy of gain between the pigs in groups II, III and IV. This was of particular interest as the procaine penicillin supplemented ration (III) was much more expensive than the other rations. This is reflected in the details of the cost of meal per pound liveweight gain (Table 4). The high mixed protein ration gave by far the most economic results.

As in the first experiment reported by Payne *et al.* (1954) the pigs fed the high mixed protein ration (I) required far less greenfeed than those fed the other three rations. The differences in green feed intake between the pigs in Group I and Group II were significant ($p=0.05$) and between Group I and Groups III and IV highly significant ($p=0.01$). Pigs in Group III consumed significantly less greenfeed than those in Group III ($p=0.05$) and those in Group IV ($p=0.01$). The addition of a procaine penicillin supplement to a plant protein diet also significantly reduced the amount of green feed consumed ($p=0.05$).

Details of the weight at slaughter, the killing percentage and certain body measurements are given in Table 6. The average weight at slaughter was well above 120 pounds owing to the difficulty of getting the butcher to accept the pigs at a specified time. The killing percentage of Group III pigs was significantly higher ($p=0.01$) than that of Groups I, II and IV pigs and that of Groups I and II pigs significantly higher ($p=0.01$) than that of Group IV pigs. Otherwise there were few major differences in carcass measurements with the exception that the carcasses of Group I pigs were not

quite as fat as the others and that the kidney weghts were higher. It is of some interest to note that the addition of a procaine penicillin supplement to a plant protein ration increased the kidney weight of the pigs.

In this trial a pig on treatment I developed an umbilical hernia on 24th May, 1954. The animal was left in the experiment and its growth did not appear to be unduly affected by the hernia.

Trial II.—Details of the growth rate of the pigs in this trial are shown in Table 7. Growth rates in all groups were higher than in trial I, probably because the experimental animals that were used were crossbreds. Up to 90 pounds liveweight the pigs in Group II, that is those fed the optimal high mixed ration plus aureomycin supplement grew slightly faster than the pigs in Group I, though the differences in growth rate were not statistically significant. Pigs in Groups I, II and III grew significantly faster than the pigs in Group IV (the difference between the pigs in Groups I, II and IV were highly significant ($p=0.01$) and between III and IV significant ($p=0.05$) but the growth rate of the pigs in Group IV was still quite good. After the pigs weighed 90 pounds animal protein feeds were omitted from ration III and at slaughter weight (120 pounds) the pigs in Groups I, II and III had grown significantly faster than the pigs in Group IV (the differences between the pigs in groups I, II and IV were highly significant ($p=0.01$) and between III and IV significant ($p=0.05$)).

The cost of the different rations is shown in Table 8. The addition of an aureomycin supplement to the ration did not radically increase the cost as the supplement is relatively cheap.

As will be seen from Table 9 the addition of an aureomycin supplement to the high mixed ration improved the economy of gain even when the ration contained adequate animal protein, though the difference between the two groups was not statistically significant. Economy of gain in Group I and Group II pigs was significantly better than in Group IV pigs (the differences between Group I and Group IV were significant ($p=0.05$) and those between Group II and Group IV were highly significant ($p=0.01$)). The cost of meal per pound liveweight gain and green feed consumption was lowest when ration II was fed. Consumption of green feed by Groups I, II and III pigs was significantly lower than that of Group IV pigs.

DISCUSSION.

Experiments conducted in many countries in the temperate zone have shown that when pigs are fed on plant or animal protein rations (with the exception of skim or buttermilk as fed in New Zealand) growth rate and the economy of food conversion improve with the addition of penicillin and aureomycin supplements to the ration. Experimental work in the temperate zone may be summarized by quoting the conclusions of the Agricultural Research Council (1953) in the United Kingdom. Trials were conducted at six centres using 512 pigs. With the addition of an aureomycin or penicillin supplement to plant or animal protein rations the increase in daily liveweight gain averaged about 10 per cent with pigs on a ration containing fish meal, and 14 per cent with pigs fed on a plant protein ration. Improvement in food conversion efficiency averaged 6-7 per cent both with animal and plant protein rations. The effect of the two antibiotics differed at different centres but there were no significant differences in overall effect. The inclusion of either antibiotic supplement in rations had no effect on carcass quality.

The results of the two trials concluded at Sigatoka are not strictly comparable but it would appear that the procaine penicillin supplement improved the growth rate of pigs on a plant protein ration by 13 per cent in trial I, while the aureomycin supplement had little effect on the growth rate of pigs on an optimal mixed protein ration in trial II. Aureomycin also improved the growth rate of the pigs on the plant protein ration (IV) in trial II but as there was no negative control group in this experiment the extent of the improvement is unknown. Economy of gain was not improved by procaine penicil-

lin in trial I, but aureomycin improved the economy of gain by 10 per cent when a mixed protein ration was fed in trial II, and it had an unmeasured but definite effect on the economy of gain of the pigs fed a plant protein ration.

The addition of the procaine penicillin supplement to a plant protein ration did appear to significantly improve the killing percentage in trial I, and the pigs on a plant protein ration had a significantly lower dressing percentage than those fed on an animal protein ration. This is consistent with the findings of Harrington and Taylor (1955).

Only one experiment on the use of antibiotic supplements for pig feeding in the tropics has been reported to date and that is an experiment in Guatemala conducted by Squibb *et al.* (1953) where crystalline aureomycin was fed as a supplement to fattening pigs receiving maize or ripe bananas. In this experiment aureomycin increased, though not significantly, the growth of pigs fed either corn or banana rations, and also the efficiency of feed utilisation.

There is a suggestion from the evidence obtained in trial II that the addition of the aureomycin supplement was more effective in promoting growth when the pigs weighed less than 90 pounds liveweight. This is the contention of several other investigators including Robinson, Coey and Burnett (1955).

From the practical pig farmer's point of view it can be said that although procaine penicillin supplement improves the growth rate of pigs fed a ration containing plant protein only the cost of the supplement in Fiji is so high that its use is not justified. It is cheaper to use an unsupplemented plant protein ration. The aureomycin supplement is very much cheaper in Fiji and it would appear that as its use apparently improves the economy of gain even of pigs fed an "optimal" ration containing animal protein, its use is justified whatever ration is fed to the pigs. Further experimentation is necessary before this claim can be fully substantiated but pig farmers in Fiji would be well advised to try out an aureomycin supplement, particularly for feeding young pigs.

The experimental results from both trials suggest that larger quantities of greenfeed are required when vegetable protein rations are fed. No explanation can at present be given for this phenomenon, but it is of some practical importance and care should be taken to see that pigs get adequate quantities of green feed when rations containing only plant proteins are fed. It is possible that when pigs are fed on a ration containing plant protein supplemented with green feed the high intake of green feed depresses the intake of the meal ration so that total effective intake is lowered.

SUMMARY.

1. The use of procaine penicillin and aureomycin supplements in pig fattening rations have been investigated at Sigatoka and two trials have been completed. The results are of more than local importance, because as far as is known, only one other trial on the use of antibiotic supplements in pig fattening has been made in the tropics.
2. In the first trial the use of a procaine penicillin supplement added to a plant protein ration was investigated. The addition of the penicillin supplement stimulated growth but its use was not found to be economic.
3. In the second trial the use of an aureomycin supplement added to mixed plant and animal protein, and plant protein only rations, was investigated. The supplement improved economy of gain even when added to the mixed plant and animal protein ration and the use of the supplement appeared to be economic.
4. It is recommended that pig farmers in Fiji who are not feeding solely skim or buttermilk should try out the use of the aureomycin supplement with their meal rations.
5. It has been noted that larger quantities of green feed are required when a plant protein ration is fed than when the ration contains some animal protein, so that farmers feeding their pigs rations containing only plant protein should ensure that adequate quantities of green feed are available at all times.

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TABLE 1

EXPERIMENTAL RATIONS FED TO PIGS IN TRIAL I

Feed	I High Mixed Protein	II Low Mixed Protein	III High Plant Protein with Antibiotic	IV High Plant Protein
Ration A fed until the pigs weighed 70 lb—				
Molasses	5	5	5	5
Maize meal	60	60	70	70
Peanut meal	..	..	15	15
Coconut meal	20	25	10	10
Meat meal	10	5	..	..
Dried buttermilk powder	5	5	..	..
"Distafeed" (procaine penicillin supplement)	..	..	5 gm. per lb meal	..
S.E.	55.8	47.1	57.9	57.9
P.E.	13.1	12.3	13 0	13.0
Nutritive ratio	1:4.3	1:3.8	1:4.4	1:4.4
Ration B fed from 70 lb liveweight to slaughterweight—				
Molasses	10	10	10	10
Maize meal	55	55	60	60
Peanut meal	..	..	10	10
Coconut meal	10	10	5	5
Rice bran	15	15	15	15
Meat meal	5	5	..	..
Dried buttermilk powder	5	..	..	..
"Distafeed" (procaine penicillin supplement)	..	..	5 gm. per lb meal	..
S.E.	55.0	52.3	55.6	55.6
P.E.	10.3	8.7	10.5	10.5
Nutritive ratio	1:5.3	1:6.0	1:5.3	1:5.3

TABLE 2

EXPERIMENTAL RATIONS FED TO PIGS IN TRIAL II

Feed	I High Mixed Protein	II High Mixed Protein with Anti-biotic	III High Mixed Protein to 90 lb Liveweight with Antibiotic	IV High Plant Protein with Anti-biotic
Ration A fed until the pigs weighed 90 lb—				
Molasses	5	5	5	5
Maize meal	60	60	60	70
Peanut meal	..	..	..	15
Coconut meal	20	20	20	10
Meat meal	10	10	10	..
Dried buttermilk powder	5	5	5	..
"Aurofac" (aureomycin supplement)	..	0.7 gm. per lb meal	0.7 gm. per lb meal	0.7 gm. per lb meal
S.E.	55.8	55.8	55.8	57.9
P.E.	13.1	13.1	13.1	13.0
Nutritive ratio	1:4.3	1:4.3	1:4.3	1.4.4
Ration B fed from 90 lb to slaughterweight—				
Molasses	10	10	10	10
Maize meal	55	55	55	60
Peanut meal	..	..	..	10
Coconut meal	10	10	20	5
Rice bran	15	15	15	15
Meat meal	5	5	..	..
Dried buttermilk powder	5	5	..	..
"Aurofac" (aureomycin supplement)	..	0.7 gm. per lb meal	0.7 gm. per lb meal	0.7 gm. per lb meal
S.E.	55.0	55.0	54.8	55.6
P.E.	10.3	10.3	8.9	10.5
Nutritive ratio	1:5.3	1:5.3	1:6.2	1:5.3

TABLE 3

LIVEWEIGHT GAIN OF PIGS IN TRIAL I

Feed	I High Mixed Protein	II Low Mixed Protein	III High Plant Protein with Antibiotic	IV High Plant Protein
Av. weight (lb) at beginning	42.8	43.5	43.8	42.0
Av. daily gain (lb) 4/5/54 to 120 lb liveweight ..	1.13	0.87	0.81	0.65
Av. daily gain as % of Group I	100	71	72	58
No. days from 4/5/54 to 120 lb liveweight	69	88	96	121

TABLE 4

FEED INTAKE, MEAL CONSUMPTION AND COST PER POUND LIVEWEIGHT GAIN IN TRIAL I

Feed	I High Mixed Protein	II Low Mixed Protein	III High Plant Protein with Antibiotic	IV High Plant Protein
Meal consumption (lb) ration A fed to 70 lb liveweight	73.7	90.6	87.5	94.3
Ration B fed 70 to 120 lb liveweight	156.5	200.4	208.4	211.1
Total fed to 120 lb liveweight	230.2	291.0	295.9	305.4
Molasses consumption (lb)	4.4	3.6	5.0	4.8
Greenfeed consumption (lb)	41.6	59.3	86.9	118.3
Meal consumption per lb liveweight gain (lb ..	3.00	3.82	3.91	3.92
Grenfeed consumption per lb liveweight gain (lb) ..	0.53	0.77	1.12	1.51
Cost of meal per lb liveweight gain (pence) ..	10.3	12.4	14.3	12.1

COST IN PENCE PER POUND OF THE EXPERIMENTAL

TABLE 5

RATIONS USED IN TRIAL I

(November 1955 prices)

Feed	I High Mixed Protein	II Low Mixed Protein	III High Plant Protein with Antibiotic	IV High Plant Protein
Ration A fed until pigs weighed 70 lb	3.94	3.78	4.11	3.50
Ration B fed from 70 lb to slaughter weight	3.24	3.01	3.50	2.90

TABLE 6

WEIGHT AT SLAUGHTER, KILLING PERCENTAGE AND CERTAIN BODY MEASUREMENTS (TRIAL I)

Feed	I High Mixed Protein	II Low Mixed Protein	III High Plant Protein with Antibiotic	IV High Plant Protein
Weight at slaughter (lb) ..	141	138	142	134
Killing percentage	74.5	74.1	74.9	73.3
Length (ins.)	28.23	30.02	29.40	29.68
Chest depth (ins.)	11.64	11.52	12.51	11.74
Shoulder fat (ins.)	1.21	1.35	1.31	1.29
Loin fat (ins.)	0.57	0.68	0.68	0.57
Weight of kidneys (gm.) ..	221.3	198.9	193.9	167.6

TABLE 7

LIVEWEIGHT GAIN OF PIGS IN TRIAL II

Feed	I High Mixed Protein	II High Mixed Protein with Anti-biotic	III High Mixed Protein to 90 lb Liveweight with Antibiotic	IV High Plant Protein with Anti-biotic
Av. weight (lb) at beginning of experiment on 5/8/55	60.8	64.8	55.3	57.0
Av. daily gain (lb) 5/8/55 to 90 lb liveweight ..	1.35	1.38	1.25	0.94
Av. daily gain (lb) 5/8/55 to 120 lb liveweight ..	1.41	1.41	1.17	0.93
Av. daily gain 5/8/55 to 120 lb liveweight as % of Group I	100	100	83	66
No. days from 5/8/55 to 120 lb liveweight	43	39	55	69

TABLE 8

COST IN PENCE PER POUND OF THE EXPERIMENTAL RATIONS USED IN TRIAL II

(November 1955 prices)

Feed	High Mixed Protein	High Mixed Protein with Anti-biotic	High Mixed Protein to 90 lb Liveweight with Antibiotic	High Plant Protein with Anti-biotic
Ration A fed until pigs weighed 90 lb	3.94	4.00	4.00	3.56
Ration B fed from 90 lb to slaughter weight (120 lb)	3.24	3.29	2.89	2.96

TABLE 9

FEED INTAKE, MEAL CONSUMPTION AND COST PER POUND LIVEWEIGHT GAIN IN TRIAL II

Feed	I High Mixed Protein	II High Mixed Protein with Anti-biotic	III High Mixed Protein to 90 lb Liveweight with Antibiotic	IV High Plant Protein with Anti-biotic
Meal consumption (lb) ration A fed to 90 lb liveweight	93.0	70.1	95.8	110.8
Ration B fed from 90 to 120 lb. liveweight ..	98.2	93.9	115.8	118.2
Total fed to 120 lb liveweight	191.2	164.0	211.6	229.0
Molasses consumption (lb)	3.7	4.4	5.3	3.7
Greenfeed consumption (lb)	31.5	26.1	55.8	82.2
Meal consumption per lb liveweight gain (lb) ..	3.22	3.01	3.28	3.64
Greenfeed consumption per lb liveweight gain (lb) ..	0.55	0.44	0.89	1.29
Cost of meal per lb liveweight gain (pence) ..	11.5	10.8	11.1	11.8

REVIEW . . .

FLAYING AND CURING OF HIDES AND SKINS AS A RURAL INDUSTRY

(F.A.O. AGRICULTURAL DEVELOPMENT PAPER NO. 49, MAY, 1955)

This publication covers one hundred and thirty-six pages and it is liberally illustrated. It aims to show how improved methods of flaying (skinning) and curing of hides and skins can be practised in an inexpensive way with particular reference to techniques suitable to tropical conditions.

The bulletin deals in detail with the production of hides and skins commencing with methods of slaughter, the general principles of curing including air-drying, salt-curing and pickling and goes on to discuss damage and defects due to bad handling, faulty storage and transport, and parasitic and fungal deterioration.

One copy of this publication is held at the Department of Agriculture, Suva, and more are on order. The book may be obtained direct from the Food and Agricultural Organization of the United Nations, Rome, Italy.

—A.F.S.O.

BOTANY . . .

SEED GERMINATION TESTING

A PRELIMINARY REPORT ON THE GERMINATION RATE OF BATIKI BLUE GRASS SEED

The Department of Agriculture purchased a seed germination tester during 1955. The germinator consists of an insulated water bath which is kept at a constant temperature by thermostatically controlled heating elements. The seeds are placed on blotting paper which is placed on glass bars over the top of the water bath and the blotting paper is kept damp by means of wicks which are suspended in the water. Each lot of seeds is covered by a plastic cup (see Plate 1). The germinator was designed and manufactured in Queensland, Australia and is the same type as is used by the Queensland Department of Agriculture. Its advantages are that it has been proved in a climate which is similar to that found in Fiji and that it is very much simpler and cheaper than the standard types of equipment.

The germinator was not received until November, 1955, but some tests have been carried out on Batiki blue grass (*Ischaemum aristatum* Linn.) seed and some interesting results have been obtained. A brief note on the results, which must be considered as being preliminary ones, follows together wth a summary of the tests which are planned for the next eighteen months.

The grass seeds were collected from the Pasture Seed Production Farm at Dobuilevu and from the Plant Introduction and Quarantine Station at Naduruloulou. Thirty-six samples were collected and they were taken at different times before, during and after the harvest. The samples were harvested on the stalk, placed in bags and then "threshed". Each sample was then divided into two lots, one lot being dried in the sun and the other in the oven at 50°C. The samples were all collected in June, 1955, but the tests were not started until the middle of November. The seeds were stored in screw-top jars while waiting for testing.

Each test consisted of four lots, each of one hundred seeds of (*a*) the sun-dried and (*b*) the oven-dried seeds of each sample. Tests were made at 30°C; 35°C and 40°C and it was decided that 35°C was the most suitable temperature for testing Batiki Blue Grass. Selected samples were retested at this temperature with satisfactory results.

It was expected that germination rate of the Naduruloulou seed would be lower than that of the Dobuilevu seed because of the heaver rainfall in the former area. This was found to be true, the Dobuilevu seed givng a very much higher percentage germination. It was also noted that in most of the tests the oven-dried seed had a higher percentage germination than the sun-dried—this suggests that a worthwhile increase in germination could possibly be obtained if the seed was artificially dried as soon as it was harvested. The highest germination recorded was 46 per cent. It was found that the greatest number of seeds germinated on the third and fourth days after the commencement of the tests. Little trouble was experienced with moulds probably because the tests were completed by the eighth or tenth day.

The following is a summary of the results :—

Origin of Seed:	(*a*) Sun-dried (Average)	(*b*) Oven-dried 50°C (Average)	Average of (*a*) & (*b*)
P.S.P.F. Dobuilevu (18 samples)	23 per cent	26 per cent	24.5 per cent
P.I. & Q.S. Naduruloulou (18 samples)	12.5 per cent	13.5 per cent	13 per cent

These preliminary tests have provided much valuable information regarding the operation of the germinator and the testing of Batiki Blue Grass. The results obtained to date can only be considered as being approximate but it is intended to carry out further tests as follows :—

Samples will be collected from the 1956 harvest and they will be divided into two lots for drying. The samples will then be stored

in screw-top bottles and in cloth bags and tested at monthly intervals for the next eighteen months. These tests should provide the following information :—

(*a*) The advantage, if any, of artificial drying over sun-drying.

(*b*) The differences, if any, between different methods of storage.

(*c*) The effects of storage.

(*d*) The age at which the seed gives the highest percentage germination.

(*e*) The germination rate for each month.

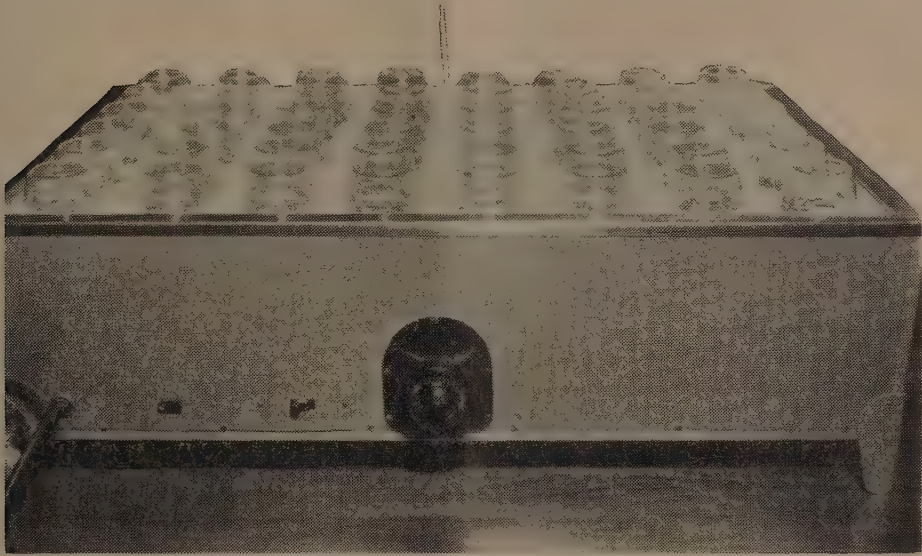

Plate 1—The germinator showing grass seeds being tested. There are one hundred seeds under each of the plastic covers.

These tests should provide valuable information on the viability of the seed of this grass and the information should be of use in any field experiments which might be devised to investigate the habits of the seed.

When the Batiki Blue Grass tests are concluded tests will be carried out on the other important pasture and fodder grasses of the Colony.

—J.W.P.

NOTES ON AGRICULTURAL RESEARCH

BY B. E. V. PARHAM

I. RESEARCH PROJECTS UNDERTAKEN WITH ASSISTANCE FROM COLONIAL DEVELOPMENT AND WELFARE RESEARCH FUNDS

Biochemical Investigations.—These investigations originally instituted under the Colonial Development and Welfare Scheme have now been taken over by the departmental services.

In connexion with the pasture and fodder programme at agricultural stations, a total of 1,321 samples of dried grasses, involving 1,837 analytical determinations, mainly for nitrogen, but including crude fibre, calcium and phosphorus have been dealt with during the year.

The data accumulated will, in due course, show the approximate relationship which exists between protein and mineral yields per acre and the various treatments which have been applied.

A general purpose grass and grain dryer has been installed at the Agricultural Station, Sigatoka, and will be used in the investigation ot the economics of preparation of grass and legume meals for incorporation in locally manufactured livestock feeds.

Botanical Investigations.—Work has made good progress. The first bulletin on the "Grasses of Fiji", comprising 166 pages and 73 illustrations, describing 159 species was completed for publication. Laboratory and field work on the material for the second bulletin on the weeds of the Colony has reached an advanced stage.

Attention has also been given to the economic flora of the British Solomon Islands Protectorate where collections have been made by arrangement with the Entomologist. Material from Pitcairn Island, Western Samoa and Niue Island has been assembled for study.

Collaboration with overseas botanical research institutions has developed in connexion with biological screening programmes, taxonomic and cytological studies of grasses, palms and taxads and work on medical properties of indigenous plants. Seed testing has been instituted, and several articles on the grasses and weeds were published in the *Agricultural Journal.*

Plant Pathological Investigations.—A preliminary list of over 200 plant diseases was compiled for circulation to research workers, and data recorded on major crop pathogens and their control under local conditions.

A field spraying trial for control of banana leaf-spot disease was instituted. Other investigations have included a preliminary study of legume *Rhizobium* on *Centrosema*, seedling blight of cocoa caused by *Phytophthora palmivora* and pod rot caused by *Botryodiplodia theobromae.*

II. RESEARCH UNDERTAKEN BY THE DEPARTMENT OF AGRICULTURE

Plant Introduction.—The regional programme of the introduction and distribution of economic plants, conducted in collaboration with the South Pacific Commission was received at a conference held at Canberra, A.C.T. in May. A five year plan of development for the Fiji station has been prepared.

In Fiji, during the year, 494 introductions were made including several valuable collections of cacao, black pepper, arabian coffee and a number of grasses, legumes and fruit trees new to the region. Distributions of economic species were made to all the associated territories.

The station is collaborating with research workers in several directions: Dr. R. Cooper's collection of Pacific edible aroids has been established at Naduruloulou; and nucleus plantings of all cocoa clones have been established for observation and propagation locally. Valuable collections of local food plants have been assembled.

Animal Husbandry. The animal husbandry work has made marked progress. Reports on pig and goat husbandry, fishpond culture and pasture improvement have been published locally and overseas. The further study of dairy cattle management in the tropics is temporarily postponed pending the arrival from New Zealand of identical twin heifers.

Four Santa Gertrudis bulls were introduced early in the year from King Ranch, Australia, and a local breeding programme has been initiated.

Crop Research has been concerned with rotation trials for bananas and sugar cane ; rice and other food crop variety trials, and fertilizer trials for banana, rice, pastures and root crops. Recently introduced rice varieties from Malaya have proved superior and distribution to growers is in hand.

Weed Control investigations have now reached a stage where early publication of results covering the control of the important local noxious weeds is possible. Advisory articles were published in the *Agricultural Journal*.

Entomology.—Local investigations on the control of the coconut beetle *Oryctes rhinoceros*, have been continued. By arrangement with the Commonweath Institute of Biological Control, large importations of predatory beetles of the families *Histeridae* and *Elateridae* were made from Trinidad. More than 9,000 *Leionota* spp. and 2,700 *Pyrophorus* spp. were liberated. The successful introduction from Hawaii of the fruit fly parasite, *Opius oophilus* was confirmed. Breeding and liberation of the moth, *Blepharomastix acutangulalis*, a leaf roller which defoliates the weed *Lantana*, continued throughout the year. Six hundred adults and 2,000 larvae of this moth and small numbers of adults and larvae of a second moth, *Diastema tigris*, were liberated.

Cockroaches parasitized by the wasp, *Ampulex compressa* were imported from Hawaii.

Arrangements were completed for a search to be made in Papua-New Guinea by an experienced entomologist for parasites of *Nacoleia octasema*, the scab moth pest of bananas.

Further attention has been given to the egg parasites (*Paranastatus* spp.) of the coconut stick insect (*Graeffea crouani*) and two trials for control of rats by means of aluminium strip bands were undertaken.

A number of different predatory and parasitic species were sent overseas to assist biological control measures and 107 series of insects were collected for the Commonwealth Institute of Entomology.

Chemistry.—Field work of the soil survey has been completed for Vanua Levu and a final report for all Fiji, complete with maps, is being prepared. Major soil types have been assessed for their power to fix phosphate. The conditions necessary for increasing the present low production of paddy soils have been defined.

Laboratory-scale fermentation of cocoa beans is assisting in the selection of good quality planting material. Cocoa is also beng studied in the field on acid and phosphate-deficient hill soils : so far lime and super-phosphate have not increased growth rate.

The Biochemist has successfully utilized the Wadsworth-Howat technique for the fermentation of cacao from single pods. The cocoas from 55 selected trees have been fermented for assessment of flavour quality. The first reports have been generally very satisfactory, indicating that there is no lack of first-class planting material in the Colony.

Work is being continued with copra drying research, with particular reference to conditions of high temperature and artificially elevated humidity. Analyses of copra have been undertaken as part of an experiment to determine the amount of deterioration in various grades of copra when stored and shipped overseas.

WEED CONTROL . . .

LANTANA AND ITS CONTROL IN FIJI

BY J. W. PARHAM, T. L. MUNE AND B. A. O'CONNOR

[The shrub *Lantana* is a well known weed in most tropical and sub-tropical countries and is locally most troublesome in coconut plantations and on grazing areas, both hill and flat land, especially where the terrain is rough or rocky and not amenable to direct mechanical operations.

In Fiji, it is proclaimed as a secondary noxious weed in one district only where limited infestations in an otherwise fairly clean area threatened to spread because of the neglect of some landholders. Elsewhere in the Colony infestations are so heavy and continuous that control by regulations is out of the questions. In these areas economic considerations comprise the most effective incentive to active control work.

In the following article the authors review briefly the results of local experimental work which indicates that, tackled in the right way, this plant can be satisfactorily controlled. Unfortunately some landholders have experienced poor results, mainly owing to inadequate methods, whereas others using the recommended methods and materials, have been very successful in reducing extensive heavy stands of this weed.—Ed.]

Lantana is a declared noxious weed throughout the whole Colony and a proclaimed secondary noxious weed in the province of Tailevu. A fairly tall, woody shrub with light coloured, somewhat prickly stems and dark green, serrated leaves. The flowerheads consist of a number of small brightly coloured flowers, the colours ranging from yellow to bright orange-red. The fruit are initially green but change to a deep purple or black colour at maturity. The plant has a strong, unpleasant odour.

BOTANICAL DESCRIPTION.

Lantana camara Linn. *Family : Verbenaceae.* (*Lantana aculeatea* Linn.)
Common Names : **Lantana ; Kauboica** (F).

Medium-sized, woody shrubs, 1 to 14 feet (.3 to 4.2 m) high, stems hairy, often with short, hooked prickles. Leaves somewhat thick, rugose, scabrous above and pubescent below ; ovate or cordate-ovate, mostly short-acuminate, crenate dentate, 1 to 2 inches (2.5 to 5 cm) long and $\frac{3}{4}$ to 1 inch (1.8 to 2.5 cm) wide, petioles short. Flowers clustered in strong axillary peduncles which may not exceed the leaves. Flowers in a dense, almost flat-topped head, generally opening yellow or pink but changing to orange or bright red ; the bracts not conspicuous. Fruit globular, shiny, dark purple to black in colour at maturity.

An American species which has become widely distributed. In some temperate countries lantana is propagated in gardens but in most tropical and sub-tropical countries it has become a serious weed. It is not known for certain how or when lantana was introduced to the Colony but it now covers considerable areas on Viti Levu, Vanua Levu, Kadavu, Ovalau, Taveuni and Yasawas.

SIGNIFICANCE.

Lantana is one of the most widespread and troublesome weeds of the Colony. Where the growth is dense the desirable plants are crowded out and in many cases the carrying capacity has been reduced by at least fifty per cent. On coconut plantations it increases the difficulty of collecting the nuts, which is a factor to be considered to-day with labour shortages, and ever-increasing opportunities of more congenial employment in other industries. Besides being a major weed the plant possesses certain toxic properties, which cause poisoning and death when grazed by stock. It also offers splendid refuge for rats, wild pigs and stinging insects. It is a fallacy to consider dense lantana growth beneficial to plantations, as it must compete with the crops for the available mineral nutrients and moisture in the soil.

BIOLOGICAL CONTROL.

In the past, several attempts have been made to find parasitic insects capable of attacking lantana. Jepson introduced a small fly *Agromyza lantanae* and a few years later Simmonds introduced two butterflies,

Figure 1.—" Lantana camara " Linn. Lantana. (a) Leaves, flowers and fruits x $\frac{3}{4}$; (b) Fruit 5 ; (c) Leaf x 1 ; (d) Flower x 5.

Thecla echion and *T. bazochi*, the larvae of which were known to feed upon the flowers. None of these insects appeared to be very effective and in 1928 Simmonds successfully introduced from Hawaii the lantana bug, *Teleonemia lantanae*, which attacks leaves and flower buds (1). This insect has since been widely distributed in the Colony ; but as described by Fyfe (2) it has not proved able to exert much pressure on the weed growth. Consequently further efforts are now being made.

In 1952 the Board of Commissioners of Agriculture and Forestry, Hawaii, proposed that Fiji should join in a project to control lantana by the introduction of insects from overseas. Fiji agreed to this proposal, and subscribed £1,000 towards financing the scheme. Australia also joined in.

A number of insect species have been imported to Hawaii from Mexico. In Hawaii they are reared, and tested on a series of economic plants to ensure that they will not attack the latter. Fiji has submitted a list of plants on which insects are tested before they are brought in to this Colony. This provides an assurance that the introduced insects will not attack useful plants.

So far, two species of moths whose larvae feed on Lantana leaves have recently been imported into Fiji. These are *Blepharomastix acutangulalis*, the first shipment of which arrved in June, 1954, and *Diastema tigris*, which was first received in October, 1954. These moths have been bred in the insectary since, and liberations of each species have been made in the field. There have been several setbacks in the breeding work, due to the death of large numbers of caterpillars affected by bacterial and fungus diseases. It had been intended to carry out large-scale breeding in field cages, but so far this method has been unsuccessful. We have been informed from Hawaii that *Blepharomastix* has been recovered in the field there, but not *Diastema*. It is suspected that local parasites tend to suppress the moths.

Varous other insect species are being reared and tested in Hawaii, and these will reach Fiji in due course. The most promising are *Cerambycid* beetles whose adults destroy the young shoots and whose larvae bore in the branches and stems of lantana.

The prospects of success by biological control appear moderately good, but effective control cannot be hoped for within the next couple of years.

DIRECT CONTROL.

As already stated, little is known of its introduction to Fiji, but it was present in the Pacific Islands before the beginning of this century. During the last fifty or sixty years it has been allowed to establish itself in many places with little opposition and its eradication in a few years is not possible. In fact, lantana, along with a number of other weeds will always be present ; but there is much that can be done towards its control. It is a persistent perennial, and the periodic slashing back of the stems without further treatment is a futile waste of time and money, as new shoots rapidly develop from the cut stumps. The most successful of the older methods of control has been organised systematic uprooting of the plant, followed by planting of desirable crops or grasses, with a continued searching of the infested areas and early destruction of all fresh growth for a number of years. The cost of such an operation would be governed by the terrain, density of the weed growth and the class of labour employed. The initial weeding of an acre of dense growth would be approximately £20 with a reducing cost for each succeeding weeding if carried out at regular intervals.

Control of lantana may also be achieved by the application of weedkillers of the hormone-like group. In a number of instances complete control has been achieved by one spray application ; but re-treatments are usually necessary. Young plants up to two or three feet high do not require any pre-treatment but old established plants should be cut and the regrowth sprayed when two or three feet high.

Effective control results from spraying MCPA at the rate of three pounds of acid equivalent in one hundred gallons of water per acre. This volume will ensure that the

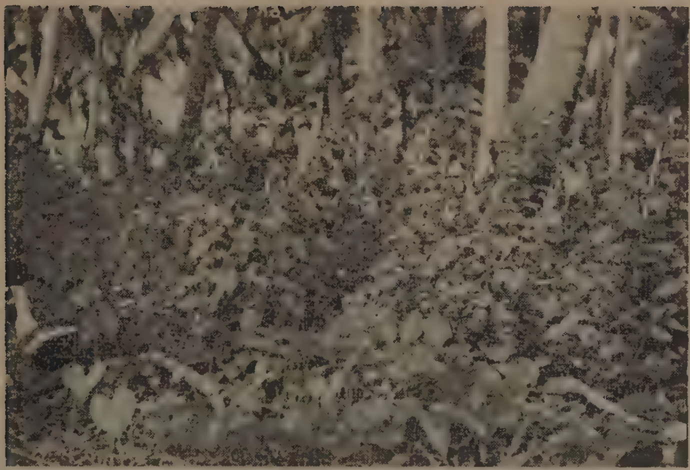
Plate 1.—Heavy lantana on coconut estate, Taveuni.


Plate 2.—Lantana control followed by planting of Batiki blue grass under constant grazing on adjacent estate to that shown in Plate 1. Note large lantana on boundary at top left-hand corner.


Plate 3.—Lantana infestation on open hill land in Taveuni.

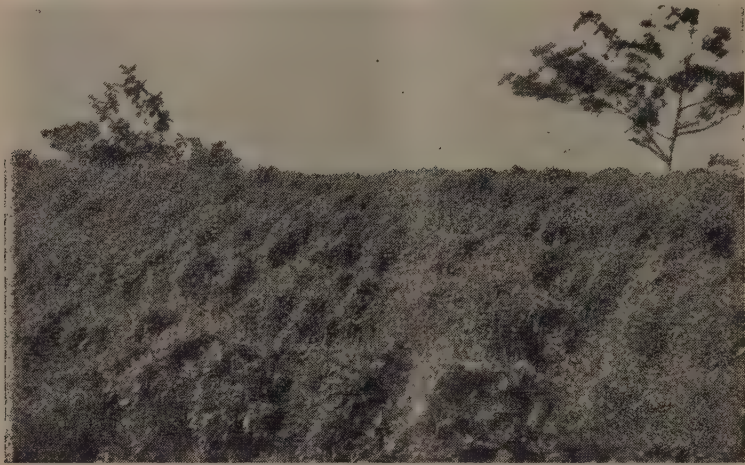

Plate 4.—Same area showing establishment of Batiki blue grass following chemical control of lantana.

stems and trunk, as well as the foliage will be thoroughly wet. This is important as incomplete coverage will result in regrowth from the missed areas. Good results have also been obtained with 2,4-D amine salts at the rate of four pounds per acre and 2,4-Dor 2,45-T esters at three point six pounds of acid equivalent per acre. The acid contents of commercial formulations is clearly shown on the label of each container.

The type of sprayer to be used will be governed by the class of land and extent of infestation. For small farms, scattered patches of weed and areas inaccessible to power sprayers, the two to three gallon knapsack sprayer carried on the operator's back is satisfactory. This delivers the liquid to a small hand boom at a pressure of 25 to 50 pounds per square inch, but experience is necessary to judge the correct amount of solution to be applied per acre. These hand-operated sprayers may be purchased at a cost of from £9-£16 each.

Where more than twenty acres is to be treated the expense of a power sprayer is warranted. The common type used for weed control is that which uses a hydraulic pump of the plunger, rotary or centrifugal type. The pump is generally mounted on a light metal frame and powered by a small Villiers, JAP or BSA engine and is easily transported on a truck, trailer or sledge. These sprayers operate one or two long hoses fitted with special hand guns delivering a jet of spray capable of penetrating dense thickets of lantana. They have been found more suitable in rough or hilly country than the standard boom sprayers developed for weed control in row crops. Power sprayers may be purchased in Suva at prices of from £89-£650.

The cost of chemical control will be governed by the type of weedkiller used, the method of application, the terrain, the density of the weed, the distance from water and the intelligence of the operator. A conservative estimate would be £12 per acre, including labour, weedkillers, two sprayings and grassing. Anyone with a large lantana problem should consult the Department of Agriculture before embarking on clearance work.

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MARKETING . . .

THE HARVESTING, HANDLING AND PACKING OF BANANAS FOR EXPORT

BY J. NIELD

The following procedure is recommended to produce the sound, palatable fruit required on overseas markets—

A. MATURITY.

The stage of maturity at which a bunch of bananas should be cut is to some extent dependant upon climatic conditions. In the cooler months the bunch should be cut when the fruit has lost its angular appearance and has become well filled while during the warmer months cutting should take place a short time before this stage is reached as the fruit will then carry better and ripen less rapidly in transit.

Fiji Banana: Typical Bunch of "Veimama" variety—grown on tropical soil, Naduruloulou, 1954.

B. HARVESTING AND CONVEYANCE TO PACKING STATIONS.

It is of the greatest importance to ensure that bunches when being harvested or when being transported to packing stations are—

(*a*) carefully handled to avoid bruising;

(*b*) carefully stacked to prevent the fruit from becoming soiled;

(*c*) adequately protected against the sun and rain.

It is, for example, essential that a bunch should not be allowed to fall to the ground when it is severed from the plant and it is equally important that it should not be thrown into river or road transport when being conveyed to packing stations.

C. REMOVAL OF FRUIT FROM THE BUNCH.

The practice of tearing the fruit from the stem invariably causes extensive bruising which will not become apparent until the fruit begins to ripen.

A sharp knife is recognised to provide the most satisfactory means of removing fruit from the bunch but where this method cannot be employed and the work has to be undertaken by hand, the fruit should always be grasped as near as possible to the stalk end.

D. GRADING.

The greatest care should be taken to ensure that only CLEAN, WELL FORMED, MATURE fruit is selected for packing into cases The following types of fruit are totally unsuitable and should be rejected without hesitation—

(*a*) Fruit which is small, thin, malformed or of uneven shape.

Plate 1 : Showing the thin, malformed, scabby fruit which is unsuitable for shipment.

Plate 2 : Showing the small even shaped fruit that should be selected for the first layer and the method of packing.

Plate 3 : Showing a well packed second layer of fruit.

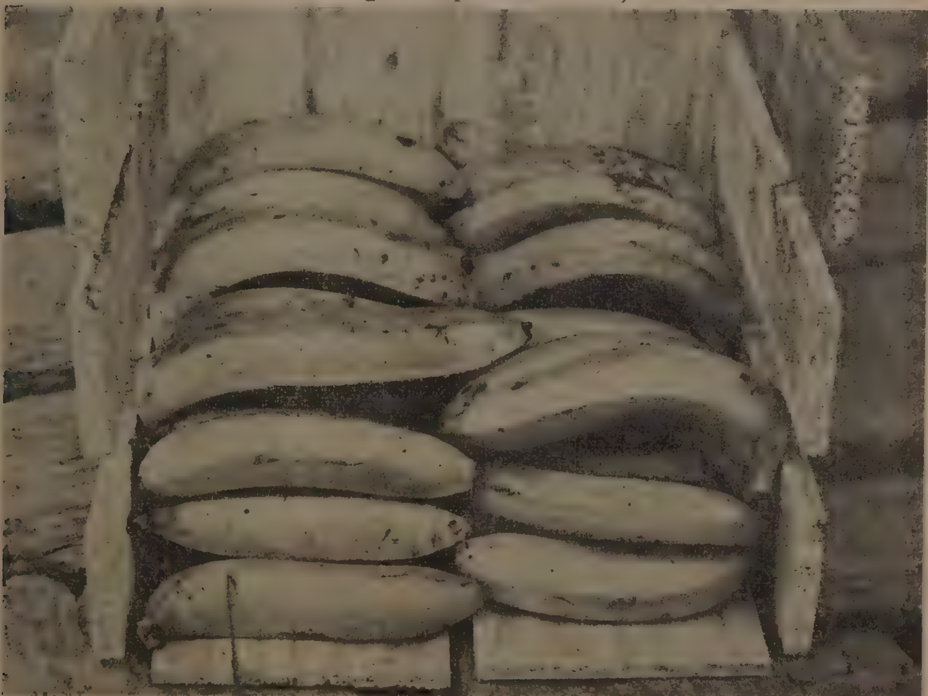

Plate 4 : Showing the gaps which are left between layers when the fruit is badly packed.

Plate 5 : Showing a badly packed first layer of fruit.

Plate 6 : The case on the left is dirty, rough sawn, unsound and badly assembled while that on the right is of clean, smooth sawn, sound timber.

(*b*) Fruit which shows any signs of scab moth damage or any other disease or blemish.

(*c*) Fruit which shows any trace of bruising or which has in any way become damaged.

(*d*) Fruit which shows any signs of ripening.

E. PACKING.

A tight and efficiently packed case of bananas can be obtained only if the first layer of fruit is firmly packed ; no matter how firm the subsequent layers may be, a case will arrive at its destination with the contents slack and bruised if the first layer has not been tightly packed.

Small even shaped fruit should be carefully selected for the first layer and should be packed tightly in the bottom of the case in the manner illustrated in Plate 2.

Each subsequent layer should be as carefully selected and as tightly packed (Plate 3), every effort being made to avoid gaps between the layers which can be seen in Plate 4.

DO NOT PLACE UNDERSIZED OR INFERIOR FRUIT IN THE MIDDLE OF THE CASE.

F. CASES.

It is essential that the cases selected for packing bananas should be of clean, smoothly sawn, sound timber and they should be strongly assembled to withstand conditions likely to be experienced during handling and transportation to their destination. Dirty, rough sawn, unsound or badly assembled cases should under no circumstances be used for fruit intended for export.

Care should be taken to remove protruding nails which can cause severe injury during handling.

Cases of packed fruit should be laid on their sides and not on the bulged bottoms or tops. Stacks of empty cases should be protected from the weather preferably by storage in a shed.

PLANT PROTECTION . . .

SURVEY OF SOME SPRAY APPLICATION PROBLEMS IN FIJI

BY G. G. TAYLOR, M.Sc.*

[During 1954, Mr. T. J. McKee, Managing Director of Messrs Fruit Growers' Chemical Co. Ltd., of Mapua, Nelson, New Zealand visited Fiji. His attention was drawn to some of the local problems, common to most tropical climates, whch complicate the normal methods of crop pest and disease control in the Colony : and he indicated that his Company would, if so desired, make available the services of its Specialist Consultant, Mr. G. G. Taylor, M.Sc., to investigate the problems on the spot in the light of the most modern practices overseas. Mr. Taylor is a Plant Pathologist with a world-wide experience in this particular field of plant protection : and on the recommendation of the Agricultural Advisory Council, Government arranged for his visit to Fiji. His report is now published in the *Journal*, and with his concurrence, the observations of several specialist officers of the Department are interpolated at the relevant parts of the report which is recommended for careful study by all concerned with or interested in the ever increasing struggle to improve the efficiency of the Colony's crop production by the control of destructive bacteria, fungi and insects.

It must be recognized, in the first instance, that the general use in Fiji of regular spraying for control of crop pests and diseases is limited by factors of climate, topography and technical know-how. The frequent heavy rainfall experienced during a greater part of the year, especially in banana areas, is a major problem which often baffles even the best instructed farmer. The scattered distribution of banana plantings, and their small size, reduces the opportunities for power spraying no less than the difficult topography which hampers the ready movement of equipment and supplies. The growers generally are not familiar with even the simplest methods and techniques nor do they have any confident appreciation either of the nature of the organism to be controlled or of the efficiency of the treatment involved.

For many years extension work on pest and disease control has been discouraged by the lack of suitable appliances and the difficulties of arranging purchases of equipment and organizing supplies at the points accessible to so many widely scattered individual growers.

Modern developments in the way of dusters or atomizer sprayers which do not require water or which operate on comparatively small quantities of water do, however, encourage the hope that the use of direct methods for control of crop diseases may in the not too distant future be a practical possibility. It is certain that the effective control, even if only partial, of such a disease as Banana Leaf-spot would be an immense advantage to the grower as well as the shipper and consumer. It would give the former increased yields from smaller areas and the latter a better quality fruit more capable of surviving the vagaries of land and sea transport than is the present inferior product of diseased plants. The illustrations which appear in the following pages are taken from Departmental records and are included to support some of the observations recorded.—EDITOR.]

This survey is based on a visit to Fiji, arranged by the Department of Agriculture, and covers a period of three weeks from 23rd April to 15th May, 1955. During that time visits were made to the major producing areas with particular reference to banana, coconut and sugar production. The objective was to assess in general terms the basis on which chemical control measures against pests and diseases might be introduced into the existing pattern of agriculture.

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Plate 1—A power dusting machine used experimentally for control of pests of coconut palms and tall trees.

2. In making this survey it was soon apparent that sociological conditions, cultural traditions and economics of production were of major importance in determining the practicability of introducing new methods such as spraying and dusting. In its broad-

est sense there is a tradition of conforming to natural limitations rather than towards control of environment. This is reflected in a reluctance to capitalize farming operations such as by the purchase of spraying equipment. The cost, availability and skill of the labour force are important considerations. Many other factors contribute towards the complication of this pattern and it is inevitable that in the course of this short survey important points will have been overlooked. On the other hand, certain fundamental facts about production are lacking. For example there appears to be little factual information on the per acre yields of bananas, little is known of the effects of weed control on production in coconuts and other crops. Too often, in other countries, agricultural practices have been introduced on the assumption that they are desirable without proper consideration of their long term effects on production. Obviously these basic principles are beyond the scope of the present survey and consequently it is assumed that the control of pests, diseases and weeds is an economic agricultural objective.

COCONUTS.

3. Few crops present such a difficult problem in applied disease and pest control as that posed by the requirement of treating the crown of a coconut palm at a height of 50 to 80 feet above the ground. Conventional high pressure spray machinery could not be expected to be effective other than on the smaller palms or on the dwarf Malayan variety. Moreover the large volume of water required, weight of the laden machines and steepness of many of the plantations place severe practical difficulties in the way of this method.

4. Low volume air flow machines present more chance of success. Unless machines were developed capable of producing a greater flow of air at much higher velocity than any at present available, it would be inevitable that directional control over the spray would be lost before reaching the target. This means that existing machines would only serve to produce and disperse the spray in droplets of particle size sufficiently fine to be carried by air currents to the tops of the palms. Under these conditions deposition on the target is largely uncontrolled, much wastage by drift occurs above and below the crowns and consequently the cost of chemicals would be high relative to the results achieved. Dusting presents similar difficulties and to be successful requires some fundamental although not impossible improvements in dust formulation.

5. From an application point of view aeroplane spraying or dusting would provide the most likely chance of success. The economics of this method would have to be fully investigated and if the cost for commercial treatment seemed to be reasonably low, then trial applications would have to be arranged either by co-operation with one of the commercial pest control operators from Australa or New Zealand or with assistance of military or commercial aeroplanes based in Fiji. The costs of such trials would be high and could only be justified if estimates showed that routine treatments would be economically feasible.

6. Although coconuts do at present suffer from attack by a number of pests such as Spike-moth (*Tirathaba trichogramma*) Cococonut scale (*Aspidiotus destructor*) *Diocalandra taitensis*, etc. only, one, the Coconut Stick-insect (*Graeffea crouani*) appears to be of immediate economic significance and this only sporadically in localized areas. It is apparent that there does exist at present a biological balance which superficially, anyway, does not appear unfavourable to coconut growing. If spraying practices were introduced it would be essential that their efficiency be proven against all the pests attacking coconuts otherwise the ensuing upset in biological balance might well lead to severe damage by one or other of these pests which at present are held in check by natural enemies. It should be pointed out that once spraying practices are adopted the chances of introducing and successfully establishing new predators or parasites are considerably reduced.

In the case of Coconut Stick-insects there is a need to control epidemic centres of infestation which at times occur. Although slow and somewhat costly, the most effective method may well prove to be individual treatment of palms by climbing and hand spraying.

(The Senior Entomologist, Suva, comments as follows :—There would probably need to be two sprayings, the first to kill insects on the foliage, and the second to kill those which would hatch during the following three months from eggs on the ground or in the crown of the palm. Costs would be very high, mainly for labour.)

RECOMMENDATIONS.

7.—(i) In view of the comparatively low per acre return from coconuts the cost of chemicals and difficulties of application and the fact that a reasonably favourable biological balance appears to exist, no immediate recommendation for commercial treatment is practicable or desirable.

(ii) Although the biological balance appears favourable this is only speculation. Moreover new pests may be introduced or old ones become more damaging. Trials should therefore be established with the object of determining the possibility of pest control by chemical means and the effect this would have on a yield and on biological balance. For such trals it is recommended that one chlorinated hydrocarbon be tested e.g. DDT, one organo-phosphorus compound, preferably malathion and the combination of both materials. Palms should be treated individually, by hand treatments (see next recommendation) repeated at intervals and observation made on pest infestation status as compared with untreated palms and yields of coconuts taken by number and weight. It would be important to record dosage rates of spray applied as basis for costing large scale operations.

Trials suggested above could only be developed on a limited scale and consequently it is unlikely that the ideal type of chemical formulation or timing or dosage would be selected in the first instance. Failure to achieve effective control and unfavourable effects on biological balance should not, therefore, be taken as condemnation of chemical control until such time as all methods have been fully explored.

(iii) Control of Stick-insect presents a special problem for which a special technique of individual palms should be adopted. Each palm would have to be climbed and a spray gun and hose drawn up on a cord. The crown of the palm would then be sprayed from below, relying on the "fallout" of spray to cover upper surfaces of expanded fronds. Spray could be pumped from a small power-driven outfit. Hand operated pumps would not be as successful since 30 lb per square inch or more in pressure would be lost by gravity alone. Under some conditions and with sufficient pressure available, it may be possible to spray adjacent palms from the one position.

Materials such as lindane and DDT should be tested. Of the organo-phosphorus compounds only malathion is sufficiently safe to use since a certain amount of contamination of the operator would be unavoidable.

This type of treatment would be intended to contain and if possible eradicate an outbreak of Stick-insects. In practice, treatment of a guard area beyond the immediate centre of infection might be required.

BANANAS.

8. The two major problems are Banana Leaf-spot (*Mycosphærella Musicola*) and Scab-moth (*Nacoleia Octasema*) and for control of both of these there are in existence certain spray recommendations. Neither of these recommendations are properly applied in practice. The reasons for this are to be found in a number of directions but the principal clause seems to be that, in the case of Leaf-spot, no clear cut directions can be given which under Fijian conditions can be relied upon to give control and in the case of Scab-moth, though effective when used experimentally, the directions seem to be impractical or too tedious for the average grower to apply.

9. Increase in banana production appears to be closely associated with control of both Leaf-spot and Scab-moth and since there are no great difficulties in applying sprays it appears that, unlike coconuts, the development of chemical techniques for control are fully justified.

10. *Leaf-spot.*—This disease is undoubtedly of major importance in banana production and, under plantation conditions,

incidence is likely to become more severe than at present where small areas in comparatively isolated situations are grown. From spray trials carried out at Sigatoka and Koronivia it is apparent that standard practices leave a great deal to be desired. It is necessary, therefore, to consider the implication of certain fundamental precepts in chemical control in relation to the biology of this disease and the growth of the banana.

Plate 2—Unsprayed banana plant showing final result of leaf-spot disease : whole leaf canopy has been killed and bunch-stalk is broken by weight of still immature fruit.

11. The findings of Leach (1940, 1941) suggest that most of the infection takes place at the time the new leaf opens out and that within a few days the leaf becomes increasingly resistant to further infection. If this is true then there is a fundamental weakness in the present recommendation of applying protective sprays at intervals of several weeks. Once a leaf commences to open it can, from the closed position, become fully unfurled in two days. Thus after any round of spraying very few recently opened leaves are likely to be adequately covered prior to infection. Most of the leaves will open out between spraying and the best coverage they can carry will be similar to that of an umbrella, sprayed when rolled up and subsequently opened. In many cases leaves barely visible at the time of spraying will have grown, unfurled and become infected before the next round of spraying. Under these conditions trials with different concentrations of Bordeaux mixture or other copper sprays or with wetting agents are unlikely to have any marked influence on disease control other than by minor effects arising from redistribution of isolated areas of spray residues. The validity of these arguments depends entirely on the extent to which infection is restricted to the newly opened leaves. It seems important therefore that this point should be investigated by further studies on infection and by direct experimentation on growing plants whereby daily applications of Bordeaux at reduced strength are applied to the developing and newly opened leaves.

12. Assuming that infection occurs principally on the young leaves it is surprising to find that leaves become so regularly infected when conditions for distribution and infection by conidia must frequently be far from ideal. If, on the other hand, ascospore infection is important then the regularity of infection of young leaves standing above the sources of conidia can be more readily explained since ascospores are wind borne and do not require free water for dispersal and infection.

13. Although there is prima facie evidence for ascospore infection it is important to confirm or deny this in Fiji since it may well lead to important change in spraying practice. Thus it may be found that the current recommendation of concentrating spray on the young leaves is unrealistic and that the procedure most likely to be successful is to spray old leaves with the object of eradicating or preventing the dispersal of viable ascospores and/or conidia. The development of effective chemical treatments for eradicating sources of infection would demand careful investigation. The ultimate value of such work could perhaps be assessed in another way by systematically removing all old leaves from an isolated area of bananas. Careful observations would have to be made before commencing such a project to make certain that all sources of ascospores were

being removed. Alternatively a trial could be set up whereby all young leaves which could be potential sources of conidial infection were removed thereby restricting sources of infection to ascospores only. In commercial practice a programme of eradication would involve both the removal of old infected leaves and the use of eradicant sprays.

(The Plant Pathologist, Mr. R. B. Morwood, comments as follows :—

With respect to Banana Leaf-spot, this report deals largely with suggestions for further investigations. Those dealing with improvement in spraying technique appear desirable and could result in improved control. However it is felt that the application of present methods is so scanty that the position is not very promising. The idea of controlling Leaf-spot solely by plant hygiene, i.e. removal of all infected leaves, is not considered practicable. That does not mean that removal of spotted leaves at frequent intervals will not help to reduce infection by Leaf-spot and assist other methods of control. Again present practice lags far behind Departmental recommendations.

Since Mr. Taylor's visit, information has been obtained that in the West Indies oil based sprays of the organic carbamates

Plate 3—Power spraying for control of Banana leaf-spot disease using the Arlington 60-gallon spray outfit—Naduruloulou, 1942.

applied at low volume have been giving better results than copper sprays. This opens up another line of investigation likely to be of practical value at an earlier date than the fundamental investigations which are so desirable if time and facilities permit.)

RECOMMENDATIONS.

14.—(i) *Biological investigation.*—Although it is realized that staffing and facilities preclude a full scale investigation in Fiji there are certain infection studies which could be undertaken to confirm findings from

other research stations. For example the viability of conidia and ascospores could be tested. Simple studies could be carried out to determine the susceptibility of leaves of various ages to infection by conidia and ascospores. Spore traps could be set up to determine the distribution of ascospores and conidia in different situations and under different climatic conditions.

(ii) *Direct spraying experiments.*—By means of one or two carefully designed yet simple field experiments certain theories should be tested.

(*a*) The developing leaf of a banana palm could be sprayed every day until it had been fully unfurled for say two days. Similar leaves could be sprayed for longer periods, e.g., up to four and eight days after unfurling. For trials of this type Bordeaux sprays at considerably reduced dosages should be employed, e.g. at once tenth normal concentration. A fine mist spray should be used with sufficient of a suitable wetting agent such as lime/casein to assure even distribution. An experiment of this type would test the theory that infection occurs on the young leaves and would also serve to pin point the critical period for spray application.

(*b*) The corollary to the above experiment would be to avoid all spraying until such time as new leaves had been unfurled for various periods and then to maintain a spray coverage by frequent applications.

There is no suggestion that the above experiments represent embryo field treatments. They are intended only as infection testing studies and would provide a basis on which the practicability of field treatments could be judged.

(*c*) If as a result of the above experiments it were shown that infection does in fact occur only or principally on the newly opened leaves then conventional spray recommendations would obviously be inefficient and an entirely new approach would be required. For this purpose spray trials should be made with various chemicals with the object of eradicating sources of infection or of rendering spores sterile. Several possibilities exist and preliminary trials of these could be made by hand atomizer spraying on infected areas of leaf and by subsequent laboratory testing for spore germination. Materials available commercially such as mercury compounds, chloronitro benzenes, naphthaquinones (Phygon), carbamates such as ferbam and captan would be worthy of trial together with strong solutions of lime sulphur.

(iii) *Crop hygiene.*—The recommendation under 2 (*c*) above aims at a method whereby sources of infection are eradicated as far as possible. Such a procedure may well prove to be the only practical approach. Removal of old infected leaves could be an important factor in reducing sources of infection. It is recommended therefore that this be tested on a small isolated block either on old bananas or on a new planting but preferably on both. The stage of growth at which leaves could be removed without affecting production would ultimately have to be determined. For purposes of this experiment, however, the growth factor could be largely ignored and by rigorous cutting out of infected leaves an attempt made to determine the maximum effect to be expected from crop hygiene. Since much of the banana production comes from small blocks, crop hygiene is a practice which, if beneficial, could well be encouraged amongst the Fijians.

An elaboration of this investigation would be to determine the stage at which ascospore production commenced and to remove only this source of infection. An important point in the epidemiology of Banana Leaf-spot could thereby be established.

15. *Scab-moth.*—A method of treatment for control of Scab-moth in Fiji has been developed by O'Connor. Whilst there is no reason to doubt the efficiency of this method it is a fact that many bananas are still attacked. In most of the plantings visited moderate to severe infection was present. Statements were made by growers that the treatment was ineffective but the most likely cause is that directions are not properly followed. This raises the question as to whether it is reasonable to expect a man to visit his banana crop every two or three days so that he can apply dust at the critical

periods. In practice it is doubtful whether this would be done. A more practical approach may be to apply insecticides with the object of achieving an overall reduction of infestation. This would certainly be of value to large plantations. In smaller areas (which constitute the great bulk of banana production) sources of reinfestation from other hosts such as *Pandanus* and *Alpinia Boia* would have to be considered. The influence of such hosts would depend on the rate of migration of moths. In practice these hosts might not be of much significance but if they were, then cutting out or spraying would have to be considered. That such hosts of Scab-moth do exist may be an advantage in that they would serve as a reservoir for predators or parasites of the Scab-moth should such ever be required.

16. For purposes of control, DDT would be a first choice. In view of the possibility of foliage injury from DDT emulsions, fine particle wettable powders of colloidal DDT formulations should also be considered. In this work malathion is worthy of trial since it may penetrate and control larvae not easily reached by DDT.

(The comments of the Senior Entomologist, Mr. B. A. O'Connor, are as follows :—

Mr. Taylor states that a more practical approach to Scab-moth control than the present method of dusting the bunches might be the application of insecticides with the object of achieving an overall reduction of infestation. In paragraph 16 he suggests DDT sprays. A trial involving the fortnightly spraying of an isolated block of bananas with DDT wettable powder has been commenced to try out this suggestion. In the meantime, the possible weaknesses of overall spraying with DDT are considered to be :—

(i) The quantity of bananas grown on large estates in Fiji is negligible, and therefore practical considerations apply only to small growers. Experience has shown that the adult Scab-moth will fly considerable distances, so that efficient control in a given area could probably be obtained only if (*a*) all growers in the area used DDT sprays or (*b*) the individual grower sprayed frequently with DDT as a permanent routine. It is considered unlikely that either of these alternative procedures would in fact be practised.

(ii) Factors which would tend to make spraying unpopular among growers are :—

(*a*) Cost.—The cost of equipment such as a knapsack sprayer and of the insecticide used would be very much greater than is the case with the dusting technique.

(*b*) Labour.—Spraying with a knapscak sprayer, which is all that most growers would have, is much more time-consuming and laborious than dusting bunches.

(iii) The effectiveness of the spraying technique in reducing infestation to an economic level is doubtful, for the following reasons :—

(*a*) The heavy and frequent falls of rain in banana growing areas make adherence to a spraying schedule very difficult.

(*b*) Assuming that spraying occurred fortnightly (about the maximum practicable frequency) there would be a fortnight's growth of unsprayed leaves and bunches between each spraying. This might permit moths to fly in and lay eggs on untreated leaves or bracts, and allow the caterpillars which hatched from these eggs to enter the unsprayed bunch. Premature washing off of the spray deposit could have a similar effect, and interruption to the spraying schedule would increase the risk.

(iv) Frequent spraying with DDT could cause infestations of other insect pests by killing off predators (mainly ladybird beetles) which at present control them. Before the introduction of the ladybird *Cryptognatha nodiceps* to Fiji in 1928, banana plants were subject to severe attacks of the scale insect *Aspidiotus destructor*. If spraying killed off ladybirds, this and other species of scale insect, and possibly red spider mites, might become severe pests.)

RECOMMENDATIONS.

17.—(i) *Biological investigations*.—Although the general outline of life history has been studied there are a number of detailed habits of the moth which could be highly important in providing successful control

measures. Apparently the moths are on hand to lay eggs in the flower bracts at a critical stage in development. Only a few bananas are at this stage at any one time. Where are the moths meanwhile ? Are they in situations where residual or contact sprays might be successful ? It would be of value to know where pupation occurs and how far the moths may be expected to migrate. These facts are important in deciding whether an attempt to eradicate Scab-moth from a banana planting would be faced by continual reinfestation from other sources.

(ii) *Control by Spraying.*—Since control of banana leaf-spot is likely to involve spraying in one form or another it seems reasonable to suggest that an attempt be made to control Scab-moth at the same time. Control of the pest may require a different technique of spraying to that for the disease. However they will each have to be investigated separately and later combined if possible in a single method to cover both requirements.

Details of experiments designed to reduce and hold the population of moths at a low level will have to be worked out in the light of the biological investigations. In practice the inital treatments aimed at eradication may be different in dosage rates and frequency of application at a low level and preventing build up. This should be taken into consideration when judging the economics of control by spraying.

(iii) *Crop hygiene.*—It has been suggested that removal of old and dead leaves may be of value in control of Banana Leaf-spot. The value of this practice or modifications of it should also be considered in relation to removal and destruction of Scab-moth pupae. The effect of clean cultivation should also be considered in relation to the insect population.

18. *Spray Machinery.*—For treating small areas, hand operated spray apparatus would appear to be the only economic method. From a practical point of view the most effective procedure would be to use a bucket pump wth a length of about 30 feet of light hose. One man would then do the pumping whilst the other sprayed. Spraying is a two handed job and on steep country it would not be possible to work an ordinary knapsack and spray at the same time. With two men and a bucket pump the work of carrying water and pumping could be shared thereby reducing the monotony and effort required and assuring a better job. The alternative is to use pressurized knapsacks. These are more costly and not so easily mantained but would have the advantage of being independent of assistance. Fortunately the Fijian variety of banana is not very tall but spraying would require the use of a lance possibly 6 feet in length. Since only a comparatively slow rate of delivery is required it is possible that lances could be fabricated from light copper tubing (say $\frac{1}{4}$ inch internal diameter) held inside a length of bamboo. The necessary junctions to carry the shut-off and nozzle would not be difficult to adapt. A swirl type nozzle such as the "Myers" using a No. 3 disc would give a reasonably good spray at pressures of 30 to 50 pounds per square inch. However for low volume work (see under Recommendations) discs of smaller size with correctly designed swirl plates would be required.

19. For areas above one acre but not of plantation size, light portable outfits mechanically driven will be required. There are several on the market used for weed spraying and the choice of these will depend on their known performance under Fijian conditions. These machines will need to be used on a co-operative basis. At least two men will be required for transportation with possibly a third for carrying water. They are quite efficient but operators will need careful training in their use and maintenance.

20. On plantations there will be a need for large scale machinery. Tractor drawn mechanically operated spray pumps of various types are available. Fully mechanized machines might be employed, i.e. by use of fixed or oscillating nozzles so that the only operator required is the tractor driver, but the method would need careful testing to determine whether leaf surfaces could be adequately covered in this way. Alternatively spray hoses could be worked from the back of each machine spraying several rows of bananas as the outfit moved along. In

this method considerable time might be lost in refilling unless provision were made for locating water tanks nearby. Under some conditions spraying operations may be held up by wet soil conditions. Another method would be to use a stationary spraying system. This method has a number of advantages and has been used successfully in South America and the West Indies in banana plantations. Details of a stationary layout designed to an area 26 acres at Naduruloulou is given in an appendix. Advantages are that several men can be working at the one time, spraying can be carried on irrespective of soil conditions and machinery is under cover and less likely to maintenance troubles than with portable outfits. The capital cost of a stationary outfit is fairly high compared with a portable machine but it should be remembered that the latter requires a tractor and part of the capital cost of this should also be added to the portable system.

21. *Recommendations.*—Whatever equipment is used an important feature will be to develop a routine method of spraying which can be readly described and which will involve the use of the minimum quantity of water. As in all hand spraying the time spent is inversely proportional to the volume of spray liquid applied. In other words by using a fine mist of spray and taking more time as efficient coverage can be obtained as by the use of large volumes of liquid applied more rapidly but with wastage from "run-off". It is recommended that some simple experiments be devised in order to provide data on which the economics of spraying could be judged and routine instructions given. The following questions could be answered.

(1) Is it more effective to spray the banana palm as a whole or to treat leaves individually ?

(2) Can a simple technique be devised and described from spraying each leaf by sweeping the spray up and down each surface ?

(3) What is the best disc size and type of swirl plate to use for spraying ?

(4) Arising from 2 and 3 above what is the least volume of spray required to give adequate coverage ?

(5) To what extent does spraying pressure affect the efficiency of coverage ?

(6) Can efficiency be improved by the use of wetting agents ?

In their simplest form the above questions could be answered by field trial and direct observation. The importance of time spent and volume applied should be emphasized. For more detailed studies chemical estimation of residual deposits would be required.

The supply of water is likely to be a limiting factor in small plantings where only manual labour is available. It is suggested, therefore, that some investigation be made of the best methods of storing water for spray purposes.

WEED CONTROL.

22. Of the various problems in Fiji involving the application of chemicals it is considered that the chemical control of weeds is most likely to be immediately productive of results of economic importance. This is really a problem of land utilization. With increasing population and the demands for diversified agricultural production for local consumption and export it seems certain that chemical control of weeds will play an increasingly important part in many different fields.

23. In nearly all its aspects the chemical control of weeds is a comparatively modern agricultural technique. On the chemical side new formulations of new materials are being developed. Their mode of action varies with species of weeds and with climatic conditions. Methods of application are dependent on many local conditions such as topography, water supply, density of vegetation and so forth. The only way to deal effectively with these problems is by direct experimentation in the field. This is being done in a highly practical manner and has already provided a basis for the development of field practice applicable to Fiji. At this stage of development it is necessary that a broad view of weed control be taken in relation to other agricultural practices. Such factors as the replacement species of grass must be considered as well as the possibility of resistant weeds of a more objectionable character becoming established. Effects of

weed control on productivity in such as banana and coconut plantations must be considered. Biological balance is a factor of high importance since removal of weeds will almost certainly affect the incidence of diseases and pests for better or worse.

24. *Coconuts.*—The field situation in regard to control of weeds on Taveuni and at Savu Savu was examined with particular reference to methods of application.

There are two distinct problems. In the first the main objective is to remove weeds and replace them with pasture. In the second the intention is to secure sufficient control over undergrowth to the extent that coconuts can be easily collected.

25. If pasture can be established successfully and economically without harm and possibly with benefit to the plantations, then weeds control can be regarded as a transient operation and not as a continuing practice. The operation is akin to control of scrub in New Zealand and its replacement with grass. Here the use of chemicals follows the initial break down of heavy gorse and blackberry by heavy discs or rollers or by bulldozing. On the flatter areas mechanical means of breaking down the heavier vegetation may prove more economic in coconut plantations with chemical treatments being used to stabilize the vegetation until grass takes over. This matter is of some importance since it affects the type of machinery and method of spraying. For heavy growth spray guns and considerable volumes of water will be required. Where the heavy growth is first removed, low volume methods using spray booms become applicable. The general assumption has been made in New Zealand that for control of undergrowth high volumes of spray are essential but there is reason to doubt this and experiments are to be undertaken using low volumes of fine spray with high velocity air as the carrying medium. Such methods may show a considerable saving in time and in cost of chemicals although the capital cost of equipment will be high. An important factor in this type of spraying will be the possibility of drift affecting growth of coconuts. This will be more important in young plantations and in the shorter Malayan varieties. Some experiments seem necessary to test the effects of hormone sprays on coconuts by direct applications to trunks and crowns of small measured dosages.

26. It is not intended to make any reference to the efficiency of various chemicals since this is a matter for local assessment. However a point of interest is that pentachlorophenol besides being an effective weed killer is also a potent insecticide. The possibility of using this to advantage in control of rhinoceros beetle or other pests including hornets should not be overlooked. Other chemicals could possibly be combined with weed sprays for a similar purpose.

27. On the hill country it seems likely chemical weed control would need to be a continuing practice. Apart from the difficulty of establishment and management of pastures on steep country, the risk of erosion may prohibit too rigid a control of vegetation. Hand spraying will be necessary. Small power units can be taken by tractor over much of the country although a certain amount of track formation will be necessary. With long hoses much of the areas can be reached with the spray outfit located on spurs and ridges. By these means the pressure lost by friction in long hoses is offset by the gain by gravity. Even so there will be a limit to the length of hose which can be economically used with small machine driven gear pumps. In practice it may be found that a high pressure force pump is required. For steep country pump operated or pressurised knapsack sprayers will be required. Whatever the method, accessible supplies of water will be essential. The only solution to this latter problem seems to be the provision of water holes, dams or even water holding tanks making use of old steel drums. The success of chemical treatments from the practical point of view will depend on various details of equipment design. Reference is made in the appendix to other sources of information.

(The Weed Control Officer, Mr. T. L. Mune, comments as follows :—Knapsack sprayers have been successfully used on very steep country for weed control and if fitted with six-foot wands and cyclone heads are not difficult to control and will reach the tops of most banana plants.

Hormone-like herbicides do not harm coconut palms unless the spray is directed into the crowns.

Pentachlorophenol is a contact herbicide and its control of local grass is of short duration and its effect on para grass practically nil.

There is no danger of soil erosion following weed control on steep hill country unless it is overstocked.)

APPENDIX I.

Requirements for Stationary Spraying Plant.—The following notes relate to the proposed development of 27 acres of bananas at the Methodist Mission, Naduruloulou.

Basic Data (estimated).

27 acres at 400 trees per acre = 10,800 trees.
100 galls per acre = 2,700 galls.
or at 200 galls per acre = 5,400 galls.

With nozzle delivery ½ gallon per minute = ½ to 1 minute per tree.

With nozzle delivery 1 gallon per minute = ¼ to ½ minute per tree.

27 acres would take minimum of 45 man hours up to maximum of 180 man hours actual spraying time. With four men spraying and one man mixing and operating the spray pump total elapsed time allowing for time lost in changing hoses between taps etc., 20 to 60 hours.

Spray Pump.—With 4 men applying 2 to 4 gallons per minute (g.p.m.), pump with rated capacity 4 or 8 g.p.m. would be advised. Pump pressure 450 pounds per square inch. The rated capacity allows for operation losses and some reserve if extra men put on to spray.

Engine—

Electric motor 2 h.p. for 4 gallons at 450 p.s.i.
4 h.p. for 8 gallons at 450 p.s.i.

Gasoline engine requires higher rating than electric motor but depends on type—should allow 3 h.p. for 4 gallons at 450 p.s.i. and 6 h.p. for 8 gallons at 450 p.s.i. This horsepower gives adequate but necessary reserve.

Pipes.—¾ inch mains, ½ inch laterals.

Hoses.—Maximum length 150 feet. Shorter lengths would save time and increase efficiency but mean more laterals and more taps.

Pressure Losses.—At maximum delivery of 1 g.p.m. per nozzle, loss of farthest point 150 p.s.i. with one man only on same ½ inch pipe. This loss will be same with four men working providing they do not draw spray from the same pipe line.

Mixing Tank.—Provided with mechanical agitation and sufficient capacity for 1 hour running viz. 120 gallons for 4 men each using ½ gallon per minute or 240 gallons for 4 men each using 1 gallon per minute. In practice due to time lost in changing taps 100 or 200 gallons capacity would be adequate. A second tank should be provided for preparation of the new mixture whilst the first is being used.

Spraying Station.—This would preferably be near centre of block because of pressure losses but will be determined by availability of water.

Water Supply.—Holding tanks required, adjacent to and above level of mixing tanks. Capacity for one days spraying viz. 2 x 400 gallon tanks or 4 x 400 gallon tanks depending on nozzle delivery rate of ½ or 1 gallon per minute. Provision would be needed to pump water from river and centrifugal pump operated by power take-off from tractor might be used.

Layout of Pipes.—Mains underground and laterals laid on surface along shelter belts. Taps spaced along laterals to give coverage over a rectangle of trees. This can easily be calculated when length of hose is determined, e.g. if the nozzle man works half way into each block from the shelter belt he will have a rectangle of approximately 90 ft. x 50 ft. and taps will be spaced 45 feet apart for a hose length of 90 feet. If nozzle-man works right across each block then with taps 50 feet apart, hose length of 150 feet required.

Additional Notes.—There are a number of details in regard to layout of pipes, operation of hoses and general installation on which advice could be given if a stationary installation is decided upon.

APPENDIX 2.

Sources of information in the United Kingdom on application machinery.

Dr. H. G. H. Kearns,
Agricultural and Horticultural Research Station,
Bristol University,
Long Ashton,
Bristol, Gloucestershire.

For advice on operation of machines in relation to spray coverage—performance of spray nozzles and light weight hand wheeled machines.

Mr. A. E. H. Higgins,
Zoology Department,
Imperial College,
Prince Consort Road,
South Kensington,
London, S.W. 7.

For advice on relative merits of commercial spraying and dusting machinery under colonial conditions.

Mr. E. R. Hoare,
National Institute of Agricultural Engineering,
Wrest Park,
Silsoe, Bedfordshire.

For information on performance of machines under standard test.

Dr. E. K. Woodford,
Unit of Experimental Agronomy,
Oxford University,
Department of Agriculture,
Park Road,
Oxford, England.

For information relating to application problems with herbicides.

PLANT PATHOLOGY . . .

A PRELIMINARY LIST OF PLANT DISEASES IN FIJI

BY R. B. MORWOOD, M.Sc.*

PLANT DISEASES IN FIJI.

This preliminary list of plant diseases in Fiji has been prepared from the published records and from observations during a survey being made for the Colonial Development and Welfare Scheme. The diseases are listed alphabetically under the common name of the host. In the first column is the scientific name of the pathogen or cause of the disease. This is followed by the common name of the disease, if available, and then a number which refers to the literature cited at the end of the list.

Among the large number of pathogens there are some which cause serious disease of valuable crops. Others are a cause of annoyance in gardens but the majority are of minor significance. Doubtless many such entries will be added as the study of plant disease proceeds. Fiji is fortunate in that several serious diseases such as swollen shoot of cocoa are not present.

BANANA—		
Virus	Bunchy top	7
Mycosphaerella musicola Leach	Leaf spot	9
Cordana musae Zimm.	Diamond spot	16
Dothidella musae	Black cross spot	10
Fusarium cubense E.F.S.	Panama disease	16
Gloeosporium musarum Cke. and Mass.	Anthracnose	2
Marasmius stenophyllus Mont.	Root rot	22
Nigrospora sphaerica (Sacc.) Mason	....	22
Phoma musae (Cke.) Sacc	Speckle	2
Tylenchus similis Cobb	Nematode	9
Uromyces musae P. Henn.	Rust	16
BARLEY—		
Helminthosporium teres Drechsler	Leaf spot	11
BEAN—		
Isariopsis griseola Sacc.	Angular leaf spot	18
Sclerotinia sclerotiorum (Lib.) de Bary	....	..
BEAN, LONG—		
Cercospora cruenta Sacc.	Leaf spot	..
Uromyces appendiculatus (Pers.) Lev.	Rust	..
BEAN, MAURITIUS—		
Cercospora cruenta Sacc.	Leaf spot	..
BREADFRUIT—		
Corticium salmonicolor, Berk and Br.	....	22
Gloeosporium artocarpi Del.	....	19
Rhizopus artocarpi Berk and Br.	....	22
CABBAGE—		
Cystopus candidus (Pers.) Lev.	White rust	12
Pseudomonas maculicola (McCulloch) Stevens	Leaf spot	22
Bacterium carotovorum (Jones) Lehman and Newman	....	22
Xanthomonas campestris (Pammel) Dowson	Black rot	21
CABBAGE, CHINESE—		
Cystopus candidus (Pers.) Lev.	White rust	19
CACAO—		
Botryodiplodia theobromae Pat.	Pod rot	22
Corticium salmonicolor B. and Br.	Pink disease	9
Fomes noxious Cornu	....	20
Marasmius scandens Mass.	....	20
Phytophthora palmivora Butler	Black pod	9
Thyridaria tarda Bancroft	....	9
Ustulina deusta (Hoffm. ex Fr.) Petrak	Root rot	20
CARROT—		
Bacterium carotovorum (Jones) Lehman and Newman	....	18
Sclerotinia sclerotiorum (Lib.) de Bary	....	..
CASSAVA—		
Cercospora henningsii Allesch	Leaf spot	30
CHILLI—		
Sclerotium rolfsii Sacc.	Crown rot	..

* Plant Pathologist, Colonial Development and Welfare Scheme, Department of Agriculture, Fiji, 1955.

CITRUS—		
Botryodiplodia theobromae Pat	....	21
Capnodium citri B. and P.	Sooty mould	21
Cassytha filiformis Linn.	Parasitic plant	..
Elsinoe fawcetti Bitanc. and Jenkins	....	..
Colletotrichum gloeosporioides (Penzig Sacc)	Scab	..
Corticium salmonicolor Berk and Br.	....	11
Penicillium italicum Wehmer	Blue mould	11
P. digitatum Sacc.	Blue mould	11
Phoma citri Sacc.	....	21
Phytophthora parasitica Dastur	Brown rot	21
Schizophyllum commune Fr.	....	21
Ustulina deusta (Hoffm ex. Fr.) Petrak	Petrak root disease	11
Xanthomonas citri Hasse	Canker	5
CLOVES—		
Peronospora sp.	....	9
COCONUT—		
Corticium penicillatum Petch	Thread blight	14
Fomes sp.	....	22
Helminthosporium sp.	Leaf spot	11
Physiological	Lightning injury	..
Graphiola cocoina Pat.	....	9
Pestalotia palmarum Cooke	Leaf spot	8
Phytophthora palmivora Butler	Bud rot	4
COFFEE—		
Cercospora coffeicola Berk. and Cooke	Leaf spot	22
Corticium salmonicolor Berk and Br.	....	22
Corticium koleroga (Cooke) V. Hohml.	....	17
Hemileia vastatrix Berk and Br.	Rust	9
Marasmius scandens Mass.	....	20
Phyllosticta coffeicola Del.	....	21
Ustilina deusta (Hoff ex Fr.) Petrak	....	21
COSMOS—		
Erysiphe cichoracearum D.C.	Powdery mildew	..
COTTON—		
Fusarium vasinfectum Atk.	Wilt	21
Mycosphaerella gossypina (Cke.) Fr.	....	1
Xanthomonas malvacearum E.F.S.	Angular leaf spot	1
COWPEA—		
Cercospora cruenta Sacc.	....	21
Sclerotium rolfsii Sacc.	....	..
CUCURBITS—		
Erysiphe cichoracearum D.C.	Powdery mildew	21
Pseudoperonospora cubensis (Berk and Curt)	Downy mildew	..
DAHLIA—		
Erysiphe cichoracearum D.C.	Powdery mildew	21
DAKUA—		
Aecidium balansae Cornu	Rust	..
DALO—		
Cercospora caladii Cooke var. *colocasiae* Hohn	Leaf spot	22
Phyllosticta colocasiae Hohn	....	22
Sclerotium rolfsii Sacc.	....	..
DATE—		
Graphiola phonenicis Poit.	....	10
DESMODIUM—		
Sclerotium rolfsii Sacc.	....	22
DIGITARIA PRURIENS—		
Claviceps sp.	....	21
EGGPLANT—		
Alternaria solani (Ell. and M.) Sorauer	....	22
Cercospora melogenae Welles	....	..
ELEPHANT GRASS—		
Piricularia grisea (Cooke.) Sacc.	Grey spot	..
GERBERA—		
Septoria gerberae Syd.	Leaf spot	..
GINGER—		
Pythium gracile Shenk.	....	16
Sclerotium rolsfii Sacc.	....	22
GRANADILLA—		
Alternaria passiflorae Simmonds	Brown spot	..
GUAVA—		
Capnodium guajavae Bern	Sooty mould	21
Glomerella cingulata (Atk.) S. and S.	Fruit rot	21
JACK FRUIT—		
Rhizopus artocarpi	Soft rot	19
LANTANA—		
Corticium salmonicolor Berk. and Br.	Pink rot	..
LETTUCE—		
Septoria lactucae Pass.	Leaf spot	..
Sclerotinia libertiana Fcl.	....	21

LIVISTONIA—		
Graphiola phoenicis Poit.	....	8
MAHOGANY—		
Botryodiplodia theobromae Pat.	Seedling Blight	..
MAIZE—		
Helminthosporium sp.	....	11
Puccinia sorghi Schw.	Rust	..
Sclerospora sacchari Miyake	....	22
Ustilago zeae (Beckm.) Unger	....	21
MANGO—		
Colletotrichum laginarum (Pass.) Ellis and Halst.	Anthracnose	1
PAPAW—		
Mycosphaerella caricae Syd.	Leaf spot	22
Phytophthora palmivora Butl.	Fruit rot, root rot	.
Virus	Yellow crinkle	..
PARA GRASS—		
Piricularia grisea (Cooke) Sacc.	Grey spot	.
Uromyces leptodermis Syd.	Rust	..
PASPALUM—		
Claviceps paspali S. and H.	....	18
PASSION FRUIT—		
Alternaria passiflorae Simmonds	Brown spot	..
PEANUT—		
Aspergillus niger Tiegh.	Crown rot	..
Cercospora personata (B. and C.) Ell. and Ev.	Leaf spot	10
Sclerotium rolfsii Sacc.	Sclerotial rot	21
PEPPER—		
Gloeosporium piperatum E. and E.	Fruit rot	11
PHLOX—		
Erysiphae cichoracearum D.C.	Powdery mildew	21
PINEAPPLE—		
Penicillium sp.	Fruitlet rot	..
Phytophthora cinnamoni Rands.	Top rot	..
Thielaviopsis paradoxa (de Seyn) v. H.	Base rot, soft rot	16
POTATO—		
Bacterium carotovorum (Jones) L. and H.	Soft rot	21
Bacterium solanacearum E.F.S.	Bacterial wilt	..
Fusarium oxysporum Fr.	Wilt	21
Phytophthora infestans (Mont.) de Bary	Late blight	21
Alternaria solani (Ell. and M.) Jones and Grout	Target spot	11
REED (*Erianthus maximus*)—		
Sclerospora northi Weston	Downy mildew	24
RICE—		
Helminthosporium oryzae Breda de Haan	Leaf spot	21
Nigrospora oryzae (Berk. and Br.) Petch	....	..
Piricularia oryzae Cav.	....	2
Sclerotium oryzae Catt.	....	21
Ustilaginoidea virens (Cooke) Takahashi	False smut	1
ROSE—		
Marssonia rosae Br.	Black spot	8
RUBBER—		
Xanthomonas albilineans (Ashby) Dowson	....	22
Botryodiplodia theobromae Pat.	Pod rot	12
Colletotrichum falcatum Went	....	22
Corticium salmonicolor B. and Br.	Pink disease	11
Hymenochaete noxia	Brown rot	9
Pestalozzia quepini Desm.	....	9
Phyllosticta hevea Zimm.	....	21
Sphaerostilbe repens B. and Br.	Root rot	11
Sphaeronema alba Patch	....	9
Stilbum cinnabarinus	Saprophyte	11
Ustilina zonata (Lev.) Sacc.	Canker	11
SEDGE—		
Cintractia axicola (Berk) Cornu	Smut	21
SISAL—		
Colletotrichum agaves Cav.	....	8
Macrosporium lanceolatum	....	9
SORGHUM—		
Puccinia purpurea Cooke	Rust	12
SOYA BEAN—		
Sclerotium rolfsii Sacc.	....	21
STRAWBERRY—		
Mycosphaerella fragariae (Tul.) Lin.	Leaf spot	1
Virus	Crinkle	..
SUDAN GRASS—		
Puccinia purpurea Cooke	....	12

SUGAR—		
Virus	Fiji disease	23
Ceratostomella paradoxa (de Seynes) Dade	....	22
Helminthosporium sacchari Butl.	....	21
Leptosphaeria sacchari Breda de Hann	Ring spot	22
Physalospora tucumanensis Speg.	....	22
Pleocyta sacchari (Mass.) Petrak and Sydow	....	22
Puccinia kuehnii (Kruger) Butler	....	22
Sclerospora sacchari Miyake	Downy mildew	22
Sclerotium rolfsii Sacc.	....	22
Schizophyllum commune Fr.	....	22
Ustilago sacchari Rabenh.	....	21
Xanthomonas albilineans (Ashby) Dowson	....	22
Xanthomonos vascularum (Cobb) Dowson	....	22
SUNFLOWER—		
Erysiphe cichoracearum D.C.	Powdery mildew	..
SWEET POTATO—		
Albugo ipomoeae—panduranae (Schw.) Sw.	....	21
Cercospora batatae Zimm.	....	22
Rhizopus nigricans Ehrenb.	....	21
Sclerotium rolfsii Sacc.	....	22
TEA—		
Glomerella cingulata (Stonem.) Spauld and Shrenk	....	22
Guignardia camalliae (Cooke) Butler	....	22
Marasmius equicrinus Mull.	....	22
Phyllosticta theae Speschn.	....	22
Ustulina deusta (Hoffm. ex Fr.) Petrak	....	11
TOBACCO—		
Cercospora nicotianae Ell. and Ev.	Leaf spot	21
Erysiphe cichoracearum D.C.	Powdery mildew	22
Virus	Mosaic	..
Sclerotium rolfsii Sacc.	....	22
TOMATO—		
Alternaria solani (Ell. and M.) Jones and Grout	Target spot	22
Bacterium solanacearum (E.F. Sm.) Dowson	Bacterial wilt	15
Cladosporium fulvum Cooke	Leaf mould	21
Corynebacterium michiganense (Smith) Jensen	Bacterial Canker	..
Fusarium lysopersici Sacc.	Wilt	16
Heterodera radicicola	Nematode	1
Virus	Mosaic	..
Sclerotium rolfsii Sacc.	Sclerotial rot	..
Septoria lycopersici Speg.	Septoria leaf spot	1
VERBENA—		
Septoria verbenae Rob. and Desv.	....	8
YAM—		
Botryodiplodia theobromae Pat.	....	22
Gloeosporium pestis Mass.	....	6
Sclerotium rolfsii Sacc.	....	22
ZINNIA—		
Erysiphe cichoracearum D.C.	Powdery mildew	21

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A BRIEF ACCOUNT OF THE ANIMAL HEALTH POSITION IN THE CROWN COLONY OF FIJI

BY A. F. S. OHMAN

The British Crown Colony of Fiji lies between latitude 15 *degrees and* 22 *degrees south and between longitude* 177 *degrees west and* 175 *degrees east. The Colony is wholly in the tropics. It is approximately* 1,700 *miles north-east of Sydney and* 1,100 *miles north of Auckland. Samoa which comprises American and New Zealand possession lies* 500 *miles to the north-east and the Kingdom of Tonga is situated* 180 *miles to the south-east. The French possession of New Caledonia is* 700 *miles to the south-west.*

The Colony comprises over 300 islands of which 105 are inhabited. The component islands vary in size from small coral atolls to the largest island, Viti Levu which covers 4,011 square miles of the total land mass of 7,055 square miles.

CLIMATE.

Two distinct climatic divisions are recognized, a wet and a dry zone. The average annual rainfall in these two zones is 120 inches and 80 inches respectively. In both zones there is a demarcated hot and cooler season. In the dry areas, months may pass without rain being recorded. The range of temperature is between 72°—82°F. with an average daily temperature of 75°F.

POPULATION AND PEOPLE.

The bulk of the population is made up of Fijians and Indians. In 1955 the population was estimated as follows :—

Indians	160,303
Fijians	143,100
Europeans (including part Europeans)	16,208
Chinese	3,985
Others (including Rotumans) ...	9,793
Total	333,389

EXPORTS AND IMPORTS.

The main exports are sugar gold, copra, coconut oil, bananas, trochus shell, pineapples, biscuits and molasses.

Some of the main edible imports are meat goods, fish, flour, sharps, butter and eggs.

ANIMAL POPULATION.

The last census was taken in 1950 and the details were :—

	Head
Cattle	80,845
Horses	16,164
Pigs	8,615
Goats	23,787
Sheep	56
Poultry	133,764

ANIMAL HEALTH.

Fiji is unique in that the contagious and infectious diseases which ravage so many other tropical countries are not present. The viral diseases such as foot and mouth disease and rinderpest of bovines, swine fever of pigs, contagious bovine pleuro-pneumonia of cattle and rabies have never been recorded. The same can be said of the protozoan diseases, piroplasmoses, anaplasmoses and trypanosomiases. Such scourges as East Coast Fever and Texas Fever have not yet reached the colony and the tick vector of Texas Fever (*Boophilus australis* var *microplus*) has not been detected.

This must be regarded as a most fortunate position when it is known that so many neighbouring islands are without animal health services and some of the closer foreign possessions are suffering from tick-borne animal diseases.

The reasons for this happy and unique position possibly may be attributed to :—

1. The Colony's insularity ;
2. Until recently the dearth of overseas and inter-island air traffic ;

3. The fact that the Colony's geographic situation is close to Australia and New Zealand where stock replenishments are available and where few of the serious infectious and contagious diseases are present ;
4. The Colony's possession of an Animal Health and Veterinary Service whose personnel are responsible for the rigid administration of an Animals Importation Ordinance (Quarantine).

The major problems in animal health are concerned with the detection and control of tuberculosis in cattle and pigs, the control of bovine brucellosis (abortion in some herds has been reduced from an approximate thirty per cent incidence to two per cent with the use of strain 19 vaccine), the control of internal parasites of cattle, goats and horses, kidney worm (*Stephanurus dentatus*) in pigs, coccidiosis leucosis and internal parasites of poultry and the treatment of heartworm (*Dirofilaria immitis*) in dogs. Some ninety per cent of the canine population is found infected with heartworm larvae and many deaths occur from the condition if it is not treated.

Taken all in all the animal population presents problems which are usually associated with conditions of moisture, humidity and the absence of extreme vagaries of climate.

Appendix " A " attached is a compilation of the diseases and parasites of domestic animals which have been recorded in Fiji up to 30th June, 1955.

APPENDIX " A ".

DISEASES AND PARASITES OF DOMESTIC ANIMALS RECORDED IN FIJI.

Compiled at 30th June, 1955 (Ohman, A. F. S.)

CATTLE—	
(*a*) Diseases—	
Cowpox	Turbet
Coccidiosis	,,
Actinomycosis	,,
Brucellosis	,,
Botulism	Ohman
Dermatomycosis	Turbet
*Haemorrhagic septicaemia	,,
Infectious Keratitis	,,
Mastitis	,,
Tetanus	,,
Tuberculosis	,,
Lantana poisoning	,,
Noogoora Burr poisoning	Ohman
Photosensitization	,,
Syncephalestrum sp.	,,
(*b*) Endoparasites—	
Paramphistomum cervi	Turbet
Ascaris lumbricoides	,,
Ascaris vitulorum	,,
Moniezia expansa	,,
Bunostomum phlebotomum	,,
Bunostomum sp.	,,
Cooperia punctata	,,
Dictyocaulus viviparus	,,
Haemonchus contortus	,,
*Oesophagostomum columbianum	,,
Oesophagostomum radiatum	,,
* Onchocerca gibsoni	,,
Setaria cervi	,,
Strongyloides papillosus	,,
Trichostrongylus sp.	,,
Trichuris ovis	,,
(*c*) Ectoparasites—	
Amblyomma acutangulatum	O'Connor
Amblyomma cyprium	,,
Amblyomma quasicyprium	,,
Heamaphysalis bispinosa	,,
Damalinia bovis	,,
Haematopinus eurysternus	,,
HORSE—	
(*a*) Diseases—	
Tetanus	Turbet
Dermatomycosis	,,
Sporotrichosis	,,
(*b*) Endoparasites—	
Anoplocephala spp.	,,
Ascaris equorum	,,
Oxyuris equi.	,,
Strongylus armatus	,,
Srongylus edentatus	,,
Strongylus vulgaris	,,
Trichonema sp.	,,
(*c*) Ectoparasites—	
Gastrophilus nasalis	Turbet
Hippobosca equina	Baequaert
PIG—	
(*a*) Diseases—	
Mastitis	Turbet
Paratyphoid	,,
Tuberculosis	,,
Spirochaetosis	Ohman
(*b*) Endoparasites—	
Ascaris lumbricoides	Turbet
Globocephalus urosubulatus	,,
Gnathostomum hispidum	,,
Metastrongylus apri	,,
Oesophagostomum sp.	,,
Ostertagia rubida	,,
Stephanurus dentatus	,,
Trichuris trichiura	,,
(*c*) Ectoparasites—	
Demodex folliculorum var suis	O'Connor
Sarcoptes scabei	Turbet
Amblyomma acutangulatum	O'Connor
Amblyomma cyprium	,,
Acuaria spiralis	Turbet
Haematopinus suis	,,
FOWL—	
(*a*) Diseases—	
Coryza	Turbet
Fowlpox	,,
*Infectious laryngotracheitis	,,
Neurolymphomatosis	,,
Coccidiosis	,,
*Fowl typhoid	,,
*Pullorum disease	,,
*Tuberculosis	Garnett and Ohman
Dermatomycosis	Turbet
Favus	,,
(*b*) Endoparasites—	
Choanotaenia infundibulum	,,
Raillietina sp.	Garnett

* Recorded but believed not present now.

Acuria spiralis	Turbet
Heterakis gallinae	,,
Heterakis perspicillum	,,
Oxyspirua mansoni	,,
Syngamus trachea	,,
Trichuris sp.	,,
(*c*) Ectoparasites—	
Cnemidocoptes gallinae	O'Connor
Cnemidocoptes mutans	,,
Cytoleichus nudus	Turbet
Liponyssus bursa.	O'Connor
Lipeuris caponis	,,
Menopon gallinae	,,
TURKEY—	
Diseases—	
Entero-hepatitis	Turbet
GOAT—	
(*a*) Diseases—	
Infectious Keratitis	Turbet
Foot-rot	Ohman
Tetanus	,,
(*b*) Endoparasites—	
Moniezia expansa	Turbet
Haemonchus contortus	,,
Oesophagotomum columbianum	,,
Ostertagia circumcinta	,,
Strongyloides papillosus	,,
Trichuris ovis	,,
SHEEP—	
(*a*) Diseases—	
Infectious Keratitis	Turbet
Dermatomycosis	,,
(*b*) Endoparasites—	
Moniezia expansa	Turbet
Haemonchus contortus	,,
Ooesophagostomum columbianum	,,
Ostertagia circumcinta	,,
Strongyloides papillosus	,,
Trichuris ovis	,,
(*c*) Ectoparasites—	
Damalinia ovis	O'Connor
DOG—	
(*a*) Diseases—	
Distemper	Turbet
Tuberculosis	,,
Dermatomycosis	,,
(*b*) Endoparasites—	
Dipylidium caninum	,,
Ancylostomum braziliense	,,
Ancylostomum caninum	,,
Dirofilaria immitis	,,
Toxocara canis	,,
Trichuris vulpis	,,
Uncinaria stenocephala	Garnett
(*c*) Ectoparasites—	
Demodex canis	O'Connor
Otodectes cynotis	,,
Sarcoptes scabei	,,
Rhipicephalus sanguineus	,,
Trichodectes canis	,,
Ctenocephalides canis	,,
Ctenocephalides felis	,,
CAT—	
(*a*) Diseases—	
Panleucopenia	Turbet
Tuberculosis	,,
Dermatomycosis	,,
(*b*) Endoparasites—	
Dipylidium caninum	,,
Ancylostomum braziliense	,,
Ancylostomum caninum	,,
Toxocara mystax	,,
Trichuris vulpis	,,
(*c*) Ectoparasites—	
Notoedres cati	O'Connor
Otodectes cynotis	,,
Sarcoptes scabei	Turbet
Ctenocephalides felis	O'Connor

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REVIEW . . .

CONSULTATIONS ON PLANT COLLECTION AND INTRODUCTION (CANBERRA, MAY, 1955)

The following is a review of the report of a meeting held in Canberra between 2nd and 7th May, 1955, which was arranged by the South Pacific Commission. The object of the consultations was to prepare recommendations concerning the possible development of a long-term regional plant introduction programe covering :—

(*a*) The evaluation and improvement of indigenous and introduced economic and subsistence plants in the region ;

(*b*) Introductions from outside the region ;

(*c*) Plant exporation ;

(*d*) Inter-territorial movement of planting material. (Proceedings of the South Pacific Commission. Thirteenth Session, paragraph 47).

Mr. Willam Hartley, Principal Plant Introduction Officer of the Commonwealth Scientific and Industrial Research Organization, Canberra, acted as Chairman. Mr. Carl O. Erlanson, Head of the Plant Introduction Section of the Agricultural Research Service, United States Department of Agriculture, also attended. Fiji was represented by Mr. B. E. V. Parham, Deputy Director of Agriculture.

The following is a review of some of the points discussed at the meeting which have been published in the ninety-five page report.

SCOPE OF PLANT INTRODUCTION.

(*a*) Plant introduction is defined as the procurement, locally or from abroad, propagation and distribution of wild and cultivated economic plants.

(*b*) The assembly of local plants for comparison with local varieties, for use in plant selection and breeding and for exchange.

(*c*) The procurement of plants may involve local or overseas exploration and exchange.

(*d*) One important point discussed was the scope of plant introduction.

It was decided that the extent to which preliminary investigation should be carried depended on the nature of the material and the availability of personnel. With new crops, plant introduction services normally take trials to a more advanced stage before handing them over to the agricultural services. It was also decided that it was *not* within the scope of plant introduction to supply the bulk quantities of seed or of planting materials ; it is only responsible for the supply of experimental quantities. Plant introduction services normally deal with other Government agencies and not with private growers. The distribution of material to the public should be undertaken by extension services and by other Government agencies.

A regional plant introduction programme should include the following activities, in order of importance :—

1. The introduction of varietal and breeding materials to supply extensive research programmes presently being carried out within the regions.

2. The introduction of plant materials of potential value for ecological areas which are considered to have priority in agricultural development.

3. The introduction of economic plants not present in the region but which appear to have possibilities.

EARLY PLANT INTRODUCTION.

Arrangements should be made for the collection of information regarding early introductions and the results of these.

ORGANIZATIONAL REQUIREMENTS.

It was proposed that the efficient organization of the plant introduction services would require :—

1. A centre responsible for the overall "direction of policy". The S.P.C. Headquarters at Noumea was suggested as being the most suitable location.

2. That the number of main introduction and plant quarantine stations be strictly limited and sited so as to cover the principal ecological divisions of the region.

3. That there be subsidiary testing centres at which introductions may be evaluated for their usefulness under local conditions.

ECOLOGICAL FACTORS.

A good basic knowledge of ecological conditions is necessary, with special reference to :—

1. Atolls.

2. Marshlands covered by swamp forests.

3. Non-seasonal high island areas with annual rainfall above 100 inches per annum and with rain forest as the main plant formation.

4. Seasonal high island areas with the annual rainfall less than 100 inches per annum and with savannah and heath as important plant formations.

5. Highlands.

REVIEW OF CROPS.

The following is a summary of the comments on the various crops which were reviewed at the Conference :—

1. Coconut—Long term scheme of improvements needed.

2. Coffee—Material at present in the region is inferior and it is suggested that improved material should be obtained from Indonesia and the United States of America.

3. Cocoa—Existing plantings in Western Samoa and Papua and New Guinea provide a source of high quality material. In Fiji the introduction of high quality material should be continued. Strict quarantine precautions are required.

4. Fibres—The material available appears to be adequate. Outstanding new strains should be introduced as they become available.

5. Bamboo and Rattan—There are great possibilities for the development of bamboo and ratan. Useful varieties could be obtained from Indonesia and Puerto Rico.

6. Oil Plants—Oil palm, tung, soya bean, sesame and castor oils should receive some attention.

7. Spices—Further introduction and selection work should be carried out on pepper but quarantine precautions should receive special attention with this crop. The spread of disease in other parts of the world may make vanilla an important crop in the Pacific. The immediate prospects of other species appear to be somewhat limited but collections of nutmegs, cloves and capsicum should be established.

8. Fruits and Nuts—There is an important need to establish reservoirs of potentially useful, improved material. Attention will have to be given to methods of vegetative propagation. Attention should be given to the following : pineapple, custard apple, bullock's heart, soursop, breadfruit, jackfruit, pawpaw, citrus, mangosteen, mango, litchi, longan, grenadilla, avocado and cashew, brazil and macadamia nuts.

9. Cereals—The possibility of inter-territorial exchanges of promising rice varieties should be investigated. It should be realized that the importation of rice seed involves quarantine problems. There is room for improvement in the selection of maize. The sorghum variety "Belleza" at Laloki has a habit suitable for the South Pacific and should be tried. Improved varieties of Job's Tears should be obtained from the Belgian Congo.

10. Subsistence Crops—There is considerable work to be done on the improvement of subsistence crops. The following programme should be adopted :—

(*a*) the selection and introduction of varieties of *Dioscorea* yams and Colocasia taro ;

(*b*) the selection of varieties of sweet potato, *Xanthosoma* taros, sweet cassava and breadfruit ;

(*c*) the introduction of suitable varieties of green vegetables ;

(*d*) the introduction of legumes with edible seeds or pods.

The programme will involve :—

(*a*) the preparation of an inventory of South Pacific varieties of subsistence crops ;

(*b*) the selection of existing stocks of potentially useful varieties ;

(*c*) the introduction, with strict quarantine precautions, to the main introduction stations, of varieties of subsistence crops from outside the region.

11. Pastures and Fodders—The assembling of the most promising pasture and fodder plants for tropical conditions should be continued. It is considered that it is desirable to continue the practice of sending officers from South Pacific territories to view pasture improvement and meet research workers in areas such as Hawaii and Queensland.

12. Other Plants—

(*a*) Forest Trees—The introduction of forest trees requires techniques which are normally within the province of Forestry Departments. The assembly and dissemination of information on a regional basis is required. Introduction stations may find it useful to supply seed of forest trees, in demand elsewhere, in exchange for planting material.

(*b*) Shade trees, cover crops, green manures—Collections should be kept at the main Introduction Stations.

(*c*) Rubber—Valuable introduction work is being carried out in Papua and New Guinea.

(*d*) Tea—Need not be included in a regional programme at the moment as there is sufficient material in the South Pacific region, especially in Papua and New Guinea, for preliminary agronomic testing.

(*e*) Sugar—Regional action is not warranted because this crop receives the attention of large commercial firms.

(*f*) Medicinal Plants—Possibilities for small scale development.

(*g*) Tobacco—Should be limited to introduction of commercial seed.

The programme outlined above will involve some expansion of activities at the present Plant Introduction Stations at Naduruloulou and Laloki.

SPECIAL PROBLEMS OF ATOLLS.

The introduction programme should include :—

1. Existing crops, especially the coconut, breadfruit, pandanus, taro and baibai.

2. Plants of high tolerance to salinity and drought.

3. Short-living shallow-rooted plants suitable for cultivation during the wet period.

There is no technical reason why plant introduction and evaluation could not be carried out on an atoll in some territory where skilled staff are within a convenient distance.

CIRCULATION AND INFORMATION.

The fields of interest of the Plant Introduction Stations should be well known so that the work of the stations may be co-ordinated most effectively. The value of personal contacts is emphasized.

PLANT EXPLORATION.

Should aim primarily at obtaining high value material which has been selected or bred in other parts of the tropical world. The South Pacific Commission should immediately make arrangements for visits by one or more qualified officers to various tropical countries, especially in south-east Asia.

MAJOR CONCLUSIONS AND RECOMMENDATIONS.

1. Plant Introduction is defined as the procurement locally, or abroad, preliminary evaluation, propagation and distribution of wild and cultivated economic plants. Plant Introduction services are responsible for the distribution of only experimental quantities of seed and planting material and normally deal with other Government Agencies.

2. The regional plant introduction programme should include the following :—

(*a*) introduction of material for current programmes of intensive research ;

(*b*) introduction of material of potential value for ecological areas ;

(*c*) introduction of economic plants not present in the region but which appear to have possibilities as new cash or subsistence crops.

3. Naduruloulou and Laloki provide a valuable service for both their own territories and for the South Pacific region as a whole.

4. Additional Plant Introduction stations are required to meet fully the requirements of the ecological zones.

5. The lack of adequate climatological and ecological information is a handicap to effective plant introduction.

6. The dissemination of information about promising varieties forms an important aspect of plant introduction.

7. Close collaboration between the activities of the stations is essential if valuable new material is to be utilized fully.

8. Plant Introduction programmed for the South Pacific must include the selection and assembly of the best local strains of established plants, inter-territorial exchange and extra-regional introduction.

9. Extra-regional plant exploration should be confined to the procurement of high value material available at agricultural centres elsewhere.

10. The arrangement of personal visits by competent experts to overseas centres of agricultural and botanical research to procure the most suitable strains for trial in the South Pacific is a matter of some urgency.

11. There is a need for more intensive introduction work with many of the cash and subsistence crops. The survey has also revealed the need for the long term potentialities of introduction studies of other plants.

APPENDICES.

The following is a list of the very interesting appendices which are presented at the end of the report :—

1. Historical sketch of Plant Introduction in the Pacific region.

2. Plant Introduction : Activities of the South Pacific Commission. A summary of discussions concerning Plant Introductions and Quarantine at S.P.C. conferences starting with the first Research Council Meeting for 1954.

3. S.P.C. Association with the Naduruloulou Plant Introduction and Quarantine Station. Brief history of this station and a list of introductions and the distribution list for 1954.

4. Schematic Ecology of the South Pacific Region : Climate, Physiography, Vegetation, Agricultural and Natural Environment, Natural Regions of the South Pacific, Plant Introduction.

5. Plant Introduction and Subsistence Agriculture : Project on native subsistence agriculture, a study of the Melanesian part of the area has just been completed. Diversification and improvement of diet. Facilitate food production and preservation. Increase food production and eliminate risks of seasonal shortage.

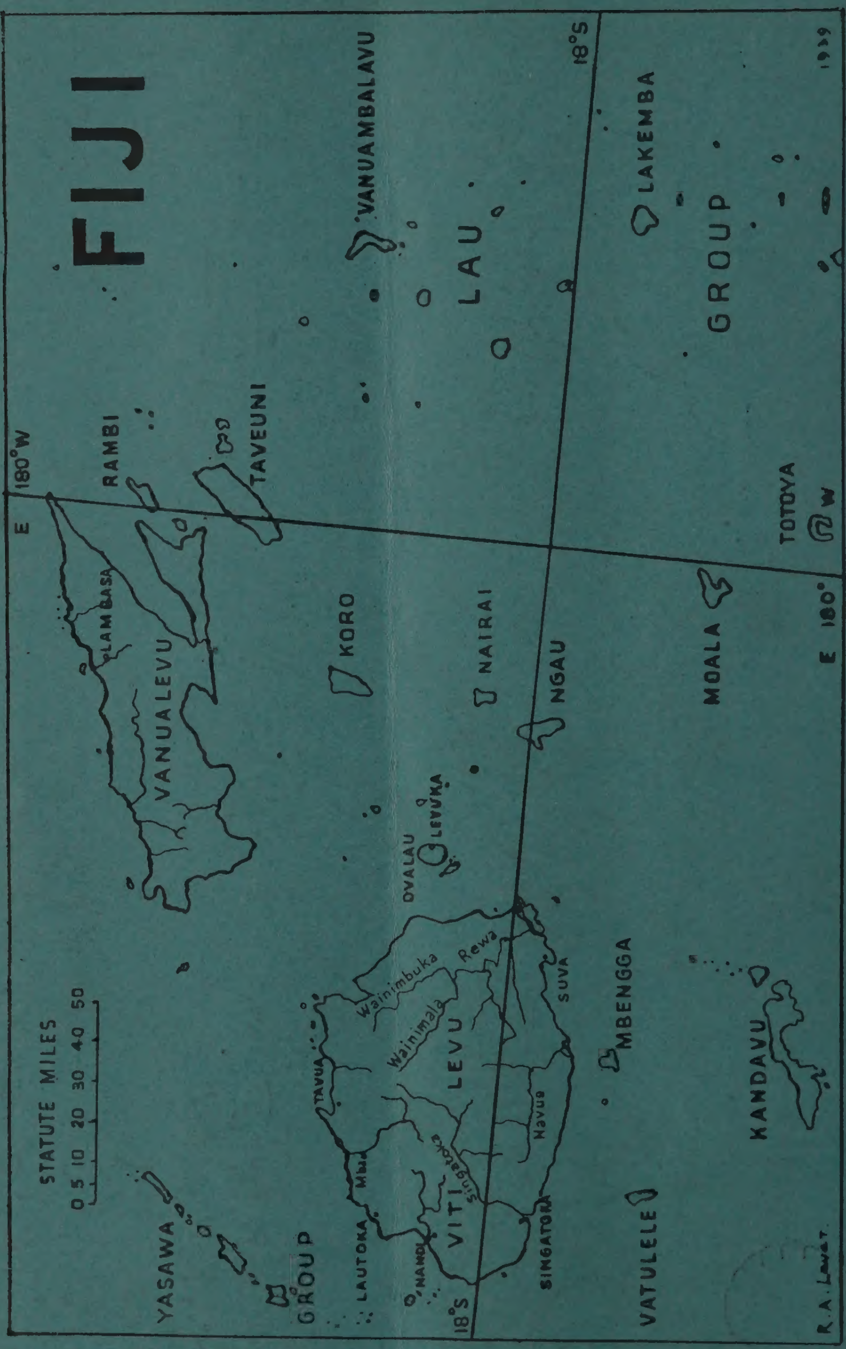
6. Territorial Plant Introduction Activities and Requirements :—

(*a*) American Samoa.
(*b*) Cook Islands and Niue.
(*c*) French Oceania.
(*d*) Guam.
(*e*) Netherlands New Guinea.
(*f*) New Caledonia.
(*g*) New Hebrides.
(*h*) Papua and New Guinea.
(*i*) Western Samoa.

7. Provisional List of Existing Agricultural Stations : A list of the stations in the South Pacific region which might be prepared to participate in a regional programme of Plant Introduction. The following are the stations listed for the Colony of Fiji :—

(*a*) Plant Introduction and Quarantine Station, Naduruloulou.
(*b*) Principal Agricultural Station, Koronivia.
(*c*) Pasture Seed Production Farm, Dobuilevu.
(*d*) Agricultural Station, Sigatoka.

J.W.P.



So as to include Kadavu and Totoya within the framework available the map has been rotated some 6° to the east.